BIOPHILIC DESIGN PATTERNS AS TOOLS FOR ENHANCING PATIENTS' HEALING AND PSYCHOLOGICAL RECOVERY IN THE DESIGN OF NATIONAL CANCER HOSPITAL, ABUJA

BY

Muawiya MAIKUDI

DEPARTMENT OF ARCHITECTURE,

FACULTY OF ENVIRONMENTAL DESIGN,

AHMADU BELLO UNIVERSITY,

ZARIA. NIGERIA

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Muawiya MAIKUDI (B.sc ARCHITECTURE, A.B.U ZARIA, 2014)

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FACULTY OF ENVIRONMENTAL DESIGN,

AHMADU BELLO UNIVERSITY,

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Declaration

I declare that the work in the dissertation entitled "BIOPHILIC DESIGN PATTERNSAS TOOLS FOR ENHANCING PATIENTS' HEALING AND PSYCHOLOGICAL RECOVERY IN THE DESIGN OF NATIONAL CANCER HOSPITAL, ABUJA."has been carried out by me in the Department of Architecture, A.B.U Zaria under the supervision of Dr. Mas'ud Abdulkarim and Dr. Amina Batagarawa. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

Muawiya MAIKUDI

Name of student	Signature	Date

.

Certification

This dissertation entitled "BIOPHILIC DESIGN PATTERNS AS TOOLS FOR ENHANCING PATIENTS' HEALING AND PSYCHOLOGICAL RECOVERY IN THE DESIGN OF NATIONAL CANCER HOSPITAL, ABUJA." by Muawiya MAIKUDImeets the regulations governing the award of Master of Science Degree in Architecture of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

_____ _____

Prof. Mas'ud Abdulkarim Date
Chairman, Supervisory Committee

_____ _____

Dr. Amina Batagarawa Date
Member, Supervisory Committee

_____ _____

Dr. A. S. Salisu Date
Head of Department

_____ _____

Prof. Sadiq Z. Abubakar Date
Dean, School of Postgraduate Studies

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Dedication

All credit is due to Allah the Lord of the Universe, and if there is any mistake in this research, it is because of me.

TABLE OF CONTENTS

Declaration .....

Certification ..... **I**

Acknowledgement ..... **II**

Dedication ..... **III**

List of Tables ..... **XI**

List of Figures ..... **XIII**

List of Plates ..... **XV**

List of Appendix ..... **XIX**

Abstract ..... **XX**

1.0CHAPTER ONE: INTRODUCTION **1**

1.1Background of Study **1**

1.2Statement of Research Problem **2**

1.3Justification **3**

1.4Aim and Objectives **4**

1.5Research Question **4**

1.6Scope of the study **4**

1.7 Thesis Outline **5**

2.0CHAPTER TWO: LITERATURE REVIEW **7**

2.1Introduction **7**

2.2Biophilia **7**

2.3The Evidence of Biophilia **8**

2.3.1Attention and restoration theory 10

2.3.2 Recovery from stress or illness 10

2.3.3Cognitive Functioning 12

2.4The Biophilic Design 12

2.4.1Organic Dimension of Biophilic Design 13

2.4.2Vernacular Dimension of Biophilic Design 15

2.5Biophilic Design Patterns 17

2.5.1 Nature in the Space 17

2.5.2 Natural Analogues 22

2.5.3 Nature of the Space 23

2.6Developing a Framework for the Integration of Biophilic Design Patterns 25

2.7Cancer 28

2.7.1 Types of Cancer 28

2.7.2Treatment of Cancer 28

2.8 Relating Biophilic Design patterns & Biological Responses to Cancer and its Treatment 29

2.9 Literature Conclusion 32

3.0CHAPTER THREE: RESEARCH METHODOLOGY 33

3.1 Introduction 33

3.2 Research Design 33

3.3 Case Studies 33

3.3.1Population of study 34

3.3.1Sampling method/ case study selection criteria 34

3.4 Data Collection 35

3.4.1Instruments for data collection 35

3.4.2 Procedures for data collection 35

3.5 Variables of the Study 36

3.6 Data analysis and presentation 37

3.7 Site Selection Criteria 37

4.0 CHAPTER FOUR: CASE STUDIES DESCRIPTION AND ANALYSIS 39

4.1 Introduction 39

4.2 Case Study One: Oncology Department, National Hospital, Abuja. 39

4.2.1Nature in the space variables 40

4.2.2 Natural analogues variables 44

4.2.3 Nature of the space variables 46

4.3 Case Study Two: Oncology Center for Excellence, Ahmadu Bello University Teaching Hospital, Shika, Nigeria. 49

4.3.1Nature in the space variables 50

4.3.2 Natural analogues variables 55

4.3.3 Nature of the space variables 56

4.3.3Analysing biophilic design patterns in ABUTH – Shika, Nigeria. 58

4.4 Case Study Three: Frauenshuh Cancer Center, U.S.A 60

4.4.1 Nature in the space variables 60

4.4.2 Natural analogues variables 65

4.4.3 Nature of the space variables 67

4.4.4Analysing biophilic design patterns in Frauenshuh Cancer Center, USA. 69

4.5 Case Study Four: Windsor Regional Cancer Center, Ontario, Canada. 71

4.5.1 Nature in the space variables 71

4.5.2 Natural analogues variables 76

4.5.3 Nature of the space variables 77

4.5.4Analysing biophilic design patterns in Windsor regional cancer center, Canada. 80

4.6 Case Study Five: Helen F Graham Center, Delaware, USA. 81

4.6.1 Nature in the space variables 81

4.6.2 Natural analogues variables 87

4.6.3 Nature of the space variables 89

4.6.4Analysing biophilic design patterns in Helen F Graham cancer center, USA. 91

4.7 Biophilic Analysis in all the Cases Studied 92

4.8 Summary of Findings 94

4.8.1Visual connection with nature 94

4.8.2Non-visual connection with nature 94

4.8.3Non-rhythmic sensory stimuli 95

4.8.4Thermal airflow & variability 95

4.8.5Presence of water 95

4.8.6Dynamic & diffuse light 95

4.8.7Connection with natural system 95

4.8.8Biomorphic forms & patterns 95

4.8.9 Material connection with nature 96

4.8.10 Complexity & Order 96

4.8.11 Prospect 96

4.8.12 Refuge 96

4.8.13Mystery 96

4.9 Survey on Psychosocial Aspect in Cancer Patients 96

4.9.1DistributionofPsychologicalDepressionsofCancer Patients 97

4.9.2DistributionofhobbyofCancer Patients 97

4.9.3CausesofPsychologicalDepressionsamongCancer Patients 97

5.0 CHAPTER FIVE: STUDY AREA 98

5.1Introduction 98

5.2Study Area Profile 98

5.2.1Site Selection Criteria 99

5.2.2 Site Selection 100

5.3 Site 'B' Analysis 102

5.3.1Visual Analysis 103

5.3.2Climatic Analysis 104

5.3.3Infrastructural Analysis 109

5.4 Effects of Environmental and Climatic Factors on Building Design 111

5.4.1Temperature 111

5.4.2Humidity 111

5.4.3Rainfall 111

5.4.4Wind pressure. 112

5.4.5Solar radiation 112

6.0 CHAPTER SIX: DESIGN REPORT 113

6.1 Introduction 113

6.2 Design Brief 113

6.3 Design Concept Synthesis 114

6.3.1Site Planning Concept 115

6.3.2Plan Concept 116

6.4 Biophilic Design Patterns Applied 117

6.4.1Visual connection with nature 117

6.4.2Non- visual connection with nature 119

6.4.3Non-Rhythmic sensory stimuli 119

6.4.4 Thermal airflow and variability 120
6.4.5Presence of water 121
6.4.6Dynamic and Diffuse light 122
6.4.7Connection with natural system 122
6.4.8Biomorphic forms & Patterns 123
6.4.9 Material connection with nature 123
6.4.10 Complexity & Order 124
6.4.11Prospect 124
6.4.12Refuge 125
6.4.13Mystery 125
6.5 Architectural Design of the Cancer Hospital 126
6.5.1General Out-patient Department 126
6.5.2Emergency Unit 127
6.5.3Clinics 127
6.5.4 In-patients wards 128
6.5.5Pharmacy 128
6.5.6Surgical department 129
6.5.7Radiology department 129
6.5.8 Radiotherapy department 130
6.5.9Histopathology unit 131
6.5.10Central sterile and supply department (CSSD) 131
6.5.11Cafeteria 132
6.5.12 Mortuary 132
6.6 Method of Construction 133
6.6.1Frame Structure 133

6.6.2Walling System 133
6.6.3Roof 134
6.6.4Floors 134
6.7 Services 134
6.7.1Power Supply 134
6.7.2Water Supply 135
6.7.3Refuse Disposal 135
6.7.4Storm Water Drainage 135
7.0 CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS 136
7.1 Summary 136
7.2 Conclusion 137
7.3 Recommendation 137
7.4 Contribution to Knowledge 138
7.5 Area of further research 139
Reference **140**
Appendix list **145**

List of Tables

Table 1.1: Thesis Organization 5

Table 2.1: Illustration of the function of biophilic design patterns on the human body... 8

Table 2.2: Biophilic response strategies 30

Table 4.1: Nature in the space description – Oncology department, National Hospital, Abuja, Nigeria 43

Table 4.2: Natural analogues description – Oncology department, National Hospital, Abuja, Nigeria 46

Table 4.3: Nature of the Space description –National Hospital, Abuja, Nigeria. 48

Table 4.4: Summary of findings in National hospital, Abuja 48

Table 4.5: Natural Analogues description – Oncology department, ABUTH – Shika, Nigeria. 56

Table 4.6: Nature of the space description – Oncology department, ABUTH-Shika, Nigeria. 58

Table 4.7: Summary of findings in oncology department, ABUTH-Shika 59

Table 4.8: Nature in the Space description – Frauenshuh cancer center, U.S.A. 64

Table 4.9: Natural Analogues description – Frauenshuh cancer center. U.S.A. 67

Table 4.10: Nature of the space variables – Frauenshuh cancer center, U.S.A. 69

Table 4.11: Summary of findings in Frauenshuh cancer centre. 70

Table 4.12: Nature in the Space description – Windsor regional cancer center, Ontario, Canada 75

Table 4.13: Natural Analogues description – Windsor regional cancer center, Ontario, Canada 77

Table 4.14: Nature of the space description– Windsor regional cancer center, Ontario, Canada. 79

Table 4.15: Summary of findings in Windsor regional cancer center 80

Table 4.16: Nature in the Space description - Helen F Graham cancer center. Delaware, USA. 86

Table 4.17: Natural Analogues description – Helen F Graham cancer center. Delaware, USA. 88

Table 4.18: Nature of the space description– Helen F Graham cancer center, USA..... 90

Table 4.19: Summary of findings in Windsor regional cancer center 91

Table 4.20: Case studies summary of findings. 92

Table 5.1: Sites' comparison 102

Table 6.1: Schedule of design brief 114

List of Figures

Figure 1: A framework for the integration of biophilic design patterns. 27

Figure 2: Biophilic analysis – Oncology department, National Hospital, Abuja. 49

Figure 3: Biophilic analysis – Oncology department, ABUTH Shika 59

Figure 4: Biophilic analysis – Frauenshuh cancer center, USA. 70

Figure 5: Biophilic analysis – Windsor regional cancer center, Ontario, Canada 80

Figure 6: Biophilic Analysis – Helen F Graham Cancer Centre. 91

Figure 7: Biophilic analysis in all the cases studied 93

Figure 8: Geographical coordinates of Abuja. 98

Figure 9: Location of site 'A' 100

Figure 10: Location of site 'B' 101

Figure 11: Location of site 'C' 101

Figure 12: Site's terrain 104

Figure 13: Monthly rainfall chart of Abuja. 105

Figure 14: Monthly temperature chart of Abuja. 106

Figure 15: Frequency polygon of Relative humidity for Abuja. 107

Figure 16: Frequency polygon of mean wind speed for Abuja. 108

Figure 5.17: Sun path diagram 108

Figure 18: Site concept 115

Figure 19: Site zoning concept 116

Figure 20: Site zoning concept 116

Figure 21: Proper segregation of parking facilities 119

Figure 22: Use of balcony planting in the in-patient department 120

Figure 23: A sketch of G.O.P.D 126

Figure 24: A sketch of emergency department 127

Figure 25: Spatial organization of a typical clinic 127
Figure 26: Spatial organization of a typical in-patient ward. 128
Figure 27: Spatial organization of a Pharamacy department. 129
Figure 28: Spatial organization of a surgical department. 129
Figure 29: Spatial organization of radiology department. 130
Figure 30: Spatial organization of radiotherapy department. 130
Figure 31: Spatial organization of histopathology department. 131
Figure 32: Spatial organization of C.S.D department. 131
Figure 33: Spatial organization of cafeteria. 132
Figure 34: Spatial organization of mortuary 132
Figure 35: A detail of expansion joint 133
Figure 36: A detail of hollow pot floor 134

List of Plates

Plate I: Natural scene image used in study. 11

Plate II: Abstract picture used in study hospital room 11

Plate III: Direct connections to nature afforded by natural light 13

Plate IV: The interior Frank Lloyd Wright's Falling water. 14

Plate V: An obvious symbolic connection to nature. 15

Plate VI: Jean Marie Tjibaou Cultural Centre, New Caledonia 17

Plate VII: New York times building. 18

Plate VIII: A fountain & garden in the Calat Alhambra, Granada. 19

Plate IX: Khoo Teck Puat Hospital, Singapore. 20

Plate X: Courtyard in Smithsonian American Art Museum, Washington DC. 20

Plate XI: CookFox Architects' New York Office through 4 21

Plate XII: Interior decorations of Tassel hotel in Brussels. 22

Plate XIII: The central Plaza of the Salk Institute 24

Plate XIV: Prospect Park in Brooklyn, New York 25

Plate XV: National Hospital Abuja, Nigeria. 39

Plate XVI: National Hospital Abuja, Nigeria. 40

Plate XVII: Warm paint of green and white. 41

Plate XVIII: A courtyard system. 41

Plate XIX: Placement of windows to capture dynamic light. 42

Plate XX: Extensive use of columns to support a covered walkway. 44

Plate XXI: Use of refined building material in the construction of the facility. 45

Plate XXII: A dome structure. 45

Plate XXIII: Properly oriented walkway to optimise visual access to outdoor vistas. .. 47

Plate XXIV: Gardens with obscured views that provide a sense of mystery. 47

Plate XXV: Approach of ABUTH-Shika. 50
Plate XXVI: Varied landscaping and vegetation. 51
Plate XXVII: Interior landscape features. 52
Plate XXVIII: Adequate provision of windows. 52
Plate XXIX: Placement of windows in courtyard 53
Plate XXX: Walkways that connects building parts into whole. 55
Plate XXXI: Fenestration network with visual access to outdoor vista. 57
Plate XXXII: A low maintenance garden. 57
Plate XXXIII: Approach of Frauenshuh Cancer Center. 60
Plate XXXIV: A healing garden 61
Plate XXXV: Exterior perspective of the facility. 61
Plate XXXVI: Interior landscape. 62
Plate XXXVII: Placement of windows to capture dynamic & diffuse light. 62
Plate XXXVIII: A water fountain. 63
Plate XXXIX: Dynamic natural lighting within patients' ward. 63
Plate XL: A wooden interior finish 66
Plate XLI: Integration of landscape features around a fenestration 68
Plate XLII: Exterior perspective of the facility 68
Plate XLIII: Approach of Windsor regional cancer center, Canada. 71
Plate XLIV: Unrestricted view of outdoor vista from the interior spaces 72
Plate XLV: Warm paint colours in interior spaces. 72
Plate XLVI: Array of windows used to allow natural ventilation. 73
Plate XLVII: A water fountain. 73
Plate XLVIII: Use of glazing to capture dynamic and diffuse light 74
Plate XLIX: Use of wood and limestone in interior finishes. 76

Plate L: Landscape elements designed around a fenestration network 78

Plate LI: Entrance of Helen F Graham cancer center. 81

Plate LII: A healing garden. 82

Plate LIII: A water garden. 82

Plate LIV: Use of warm colours in interior spaces 83

Plate LV: Extensive use of operable windows to allow natural ventilation. 83

Plate LVI: A water fountain. 84

Plate LVII: Dynamic natural light within the interior spaces 84

Plate LVIII: An existing pond around the facility. 85

Plate LIX: Use of wooden interior finishes 87

Plate LX: Proper orientation of the facility to optimise visual access 89

Plate LXI: A low maintenance garden around existing pond 90

Plate LXII: Zuma rock 99

Plate LXIII: Jabi Lake 103

Plate LXIV: Site's vegetation. 105

Plate LXV: Shehu Musa Yar'adua way 109

Plate LXVI: Power cable along Shehu Yar'adua express way 110

Plate LXVII: Varied landscaping & vegetation 117

Plate LXVIII: Ariel view of the healing garden 118

Plate LXIX: Adequate provision of windows 120

Plate LXX: Skylight over in-patients' ward 121

Plate LXXI: A water fountain. 121

Plate LXXII: Solar shading device 122

Plate LXXIII: Locating the in-patient deppartment to have visual access with Jabi lake 122

Plate LXXIV: Biomorphic (honey comb) façade of the in-patient department 123

Plate LXXV: Complex shading device that mimics the shape of water droplet 124

Plate LXXVI: Green wall system on walkways 124

Plate LXXVII: Semi-intensive roof garden 125

List of Appendix

Appendix I: Developing biophilic design conceptual framework 145

Appendix II: Case study checklist sample 147

Appendix III: Pyschological depression among cancer patients 148

Appendix IV: Hobby distribution among cancer patients 149

Appendix V: Causes of psychological depression among cancer patients 150

Appendix VI: Site Plan 151

Appendix VII: First floor plan 152

Appendix VIII: Second floor plan 153

Appendix IX: Third floor plan 154

Appendix X: Fourth floor plan 155

Appendix XI: Roof plan 156

Appendix XII: Approach and rear elevations 157

Appendix XIII: Sides eleavtions 158

Appendix XIV: Perspectives 159

Appendix XV: Biophilic design patterns applied 160

Appendix XVI: Sections 161

Appendix XVII: Detail one 162

Appendix XVIII: Detail two 163

Abstract

In 2014, the World Health Organization in Nigeria recorded 150,000 new cancer cases with an estimated mortality rate of about 80,000. Even with this frightening statistic, there are few cancer clinics and only 11 cancer registries which are located in various teaching hospitals in different parts of the country. These facilities were approached using a generic design as such the psychosocial needs of the cancer patients were not considered during the planning stage. As such, this thesis aims at developing a framework for the integration of biophilic design patterns in the design of cancer hospital, thereby creating a connection between life, nature and the built environment which evolve architecture that can positively contribute to the healing and psychological recovery of cancer patients.

Based on existing literature correlating biophilic design patterns and biological responses, strategies for the integration of biophilic design patterns were developed based on three broad patterns of biophilic design namely; Nature in the space, Natural analogues and Nature of the space. These strategies provided a design guideline on how to maintain a connection with natural world into a healthcare setting. The research type is exploratory and encompasses both the qualitative and quantitative tradition in methods of data collection through case studies and interviews.

In order to check how these strategies were adopted in the design of existing cancer hospitals, five cases were explored; two local and three foreign. The local cases are; Oncology Department, National Hospital Abuja, Nigeria and Oncology Department, Ahmadu Bello University Teaching Hospital, Shika, Nigeria. The foreign cases are: Frauenshuh cancer centre, United States, Windsor regional cancer centre, Canada and Helen F. Graham cancer centre, United States. The result shows that across all the cases studied, Nature in the space patterns were applied the most with the average score of 3.1 out of a total of 4, followed by Nature of the space patterns with the score of 2.6 Natural analogues patterns have the least score of 2.4. A synthesis of the knowledge gained through the review of related literature, the cases studied and site analysis conducted formed an articulated design framework to accomplish an ultimate goal of creating a biophilic cancer hospital, in Abuja, Nigeria. This architecture provides patients battling with cancer an environment that is inspiring, invigorative and places with soothing ambiance to reduce their cognitive and psychological stress.

1.0 CHAPTER ONE: INTRODUCTION

1.1 Background of Study

Over the centuries, the connection between healing and nature was slowly displaced as medical technology advanced and became more specialized (Davidson, 2013). There is more consciousness of infection and the necessity for sanitary conditions. New and enhanced treatments that concentrated less on the physical and more on the medical epidemiology were given attention, and the all-inclusive method to medicine was pushed aside (White, 2011). Hospitals turn into what some consider cold, sterile institutions that take over the health care industry today. However, since the 1990s there has been resurgence in nature-based care, and professionals are once again beginning to focus on the whole person, the mind, body and spirit connection in health care settings (Davidson, 2013).

The human association with nature can be drawn back to the beginning of our species and how our ancestors survived and deeply hang on the natural environment for survival. Biophilia is the theory that humans have an innate or evolutionary-based affinity for nature. It is the belief that we have a connection and a dependence on nature that has been handed throughout evolution (Wilson, 1984).

Because of its remarkable influence on human psychology, biophilia based design plays a vibrant role in healthcare delivery. The current healthcare system contains many flaws, especially in its physical spaces. Hospitals, clinics, and offices are high-stress environments for patients, visitors and families, and healthcare professionals alike. Integrating nature into healthcare facilities has abundant benefits for many groups (Heerwagen & Orians, 2011).

Cancer is a large group of diseases (over 200) characterised by uncontrolled growth and spread of abnormal cells (American cancer society, 2005). However, treating cancer is

not the same as treating the patient (Holland & Rowland, 1990). This is due to the fact that cancer is not restricted to physical effects; it also evokes emotional chaos that influences personal relationship and patient's ability to live and work (Smith, 2013). These additional impacts are referred to as one's psychosocial health.

Problems resulting from untreated psychosocial needs have been shown to bringantagonistic effects within the body's cardiovascular, immune, and endocrine systems, contributing to the decline in health associated with cancer and its treatment (Segerstom & Miller, 2004). Two of the most reported psychosocial effects in persons with cancer are anxiety and emotional distress (Stark, Kiely, Smith, Velikova, & Selby,2002).

The journey a patient battling cancer takes can be both scary and difficult (Smith, 2013). Moderatingthe fear helps patients circumnavigate the journey easier and with more confidence. While diagnosis of cancer will always come with a set of assumptions (Krump & Nordling, 2012), environment can be designed that helps the patients see hope and fortitude during their treatment.

1.2 Statement of Research Problem

While the projection for several forms of cancer have progressed over the last decade in developed countries, mostly due to immense technological and scientific developments, the vantage point remains grim in Nigeria. According to World Health Organization (W.H.O.)report on cancer country profile, about 150,000 new cases of cancer are recorded in Nigeria in the year 2014, with an estimated mortality rate of about 80,000. Regardless ofthis, there areonly 11 cancer registries which are located in various tertiary teaching hospitals in different parts of the country (Abdulkarim, 2015).

Clinical practices in these cancer registries focus mainly on "cure over care" phenomena while often neglecting the patients' psychological and spiritual needs. And since their

design is not cancer specific, they lack the required provision of natural elements fusedin their design, which aidsin connecting the patients with natural environments and for the purpose of meeting their psychosocial needs. As such this research seeks to study the healing attributes of biophilic architecture and its positive effects particularly on cancer patients, and how it will aid in enhancing their physical and psychological recovery.

1.3 Justification

Due to fast progress of new cancer cases every year in the country, it is necessary for the request of effective health care delivery to tackle cancer explicitly. The health facilities present can neither cope with such demand nor where they designed to.

I. Nigeria ranks among top 25 countries in the world (Sam, 2012) with highest cancer morbidity rate and no equivalent health care centres to tackle the demand. Moreover, an estimated figure of 80,000 deaths occurs in Nigeria in 2014, with 10 deaths recorded every 1 hour (W.H.O., 2014).

II. The release of stress hormones tends to make cancer cells more resistant to treatment, and even enhance their metastasis. As such, there is need to connect the recovering patients with natural world to enable them harness the healing attributes of nature.

III. It must be understood that health promotion is most effective by means of a holistic approach, with supportive environments proving to have the greatest impact. Thus, studying biophilia will provide an in-depth analysis on how to incorporate nature into healthcare settings thereby aiding in holistic recovery.

1.4 Aim and Objectives

The research aims at developinga framework for the integration of biophilic design patternsin the design of cancer hospital, thereby creating architecture that can positively contribute to the healing and psychological recovery of cancer patients.

The objectives are:

I. To relate explore the connection between biophilia and holistic treatment of cancer patients.
II. To explore ways in which biophilic design patterns have been integrated in the design & construction of existing cancer centres through case study approach.
III. To develop a framework for the integration of biophilic design patterns on cancer hospital.
IV. To demonstrate, through design, the integration of these patterns in designing national cancer hospital, in Abuja, Nigeria.

1.5 Research Question

The research intends to answer the following questions;

I. What aspect of biophilic design are in existence Nigerian cancer facilities?
II. How relevant arepatterns of biophilic design in creating naturalistic spaces within a hospital design, thereby stimulating the healing process and psychological recovery of cancer patients?

1.6 Scope of the study

The research hinges mostly on three broad categories of biophilic design. Namely; Nature in space, Natural analogues and Nature of space.

From a well analysis of these patterns, a detailed architectural design will be preparedthrough a conceptual design process in which these patterns will be applied in various degrees in cancer hospital. And since the design is set to become the core ofall related cancer cases in the country, it will be located in Federal Capital Territory, Abuja, North-central of Nigeria.

1.7 Thesis Outline

The thesis is organised into seven chapters as shown in Table 0.1and discussed below.

Table 0.1: Thesis Organization

Problem	**Chapter one**: 'Introduction'	
Theoretical Framework	**Chapter two:** 'Literature Review'	
Methodology	**Chapter three:** 'Methodology'	**Chapter four:** 'Case Studies'
Results	Chapter five: 'Study Area'	Chapter Six: 'Design Report'
Conclusion	Chapter Seven: 'Conclusion and Recommendation'	

Source: (Researcher, 2015)

Chapter onehighlights the research problem and presents the aims, objectives, research question &justify the need of the research.

Chapter two reviews the literature that explores different areas of influence that nature has had in benefiting human health and well-being with a particular focus on cancer patients. The review examines the biophilia hypothesis, dimensions, elements and attributes, and focuses on the found benefits of access to nature, particularly for cancer patients,

Chapter three presents the approach adopted for the study based on a conceptual/theoretical framework comprising three major components of biophilic designpatterns garnered from the review of related literature. The chapter also presents criteria employed in choosing the sample population for the survey subsequently conducted as well as ways for interpreting results.

Chapter four reports the ways in which biophilic design principles have been integrated in the design & construction of existing cancer centres through case study approach. It also presents and discussed the findings of the case studies conducted.

Chapter five titled 'Study Area' reports the conceptual/analytical ways employed through design processfor choosing site and subsequently analysing it to suite the need of the design.

Chapter six titled "Design Report" brings all data previously studied into apronounced design framework which will form the basis for the devising of design concept. All design solutions, theory and findings of the case study conducted shall be ascribed to the designing a proposed biophilic cancer hospital, in Abuja, Nigeria.

Chapter seven concludes the research work by stating its findings and recommendations. It also mentioned the contribution of the research to knowledge and projected areas of further study.

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The following literature review explores different areas of influence that nature has had in benefiting human health and well-being with a particular focus on cancer patients. Existing research studies on the physical and psychological effects of experience with nature will be examined. The review is divided into two sections.The first section examines the hypothesis, dimensions, and patterns of biophilic design. The last section of the review focus on the found benefits of access to nature, particularly for cancer patients, and the benefits of natural settings in health care facilities. The review will also discuss design considerations for incorporating nature into the built environment, as well as relating biophilic design patterns & biological responses to cancer symptoms and treatment.

2.2 Biophilia

Stemming from the Greek origins, “love of life or living systems”, the term biophilia was first invented by a German social psychologist Erich Fromm. Fromm theorized that people have a “passionate love of life and all that is alive; it is the wish to further growth, whether in a person, a plant, an idea, or a social group” (Fromm, 1973, p. 366). Wilson takes Fromm’s idea further and explains biophilia more completely. Wilson’s theory of biophilia states that humans have an inborn tendency to focus on life and lifelike processes. To elaborate, this theory sensesthat humans have a need for nature beyond what nature provides them at a physical level, and includes the human craving for aesthetic, intellectual, cognitive, and spiritual needs (Kellert & Wilson, 1993).

Precisely, biophilia is the essential human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment (Heerwagen & Mador 2009). Wilson (1984) poetically summarizes biophilia thus:

"To explore and affiliate with life is a deep and complicated process in mental development. To an extent still undervalued, our existence depends on this propensity, our spirit is woven from it, and hope rises on its currents".

Other researchers have furthered the study of biophilia such as Stephen Kellert (2008), a professor of Social Ecology at Yale University who, along with Wilson, edited the book *The Biophilia Hypothesis*. The hypothesis suggests that "humanity is intimately linked with nature on an evolutionary level, and that our well-being as humans is dependent on our continued connection and relationship with the environment from which we as organisms sprang" (Kellert & Wilson, 1993). In essence, biophilia became biologically encoded in our DNA because it helped improve our existence and survival through physical, emotional and intellectual fitness.

2.3 The Evidence of Biophilia

The evidence of biophilia has been approached by Kaplan & Kaplan (2006) based on the called attention & restoration theory, stress reduction and cognitive functioning, These are the evidenceforbiophiliaand canbelinkedtoresearchinoneormoreof threeoverarchingmind-body systems–cognitive,psychologicalandphysiological (Terrapin, 2014)–thathavebeenexploredandverifiedtovarying degrees,inlaboratoryorfield studies (Ulrich & Giplin, 2003), to help explain how people's health and well-being are impacted by their environment. To have a better understanding with these nature-health relationships, these mind-body systems are discussed in Table 2.1 to establish relationship between biophilic design patterns, biological responses and mind-body impacts.

Table 2.1: Illustration of the function of biophilic design patterns on the human body.

Pattern of Biophilic Design	**Stress Reduction**	**Cognitive Performance**	**Emotion, mood & Preference**

Nature in the Space Patterns			
Visual Connection with Nature	-Lowered blood pressure and heart rate.	-Improve mental engagement/attentiveness	-Positively impacted attitude and overall happiness
Non-Visual Connection with Nature	Reduce systolic blood pressure.	Improve mental engagement/attentiveness.	Positively impacted attitude and overall happiness
Non-Rhythmic Sensory Stimuli	Positively impacted heart rate and sympathetic nervous system activity.	Observed and quantified behavioural measures of attention and exploration	
Thermal & Airflow Variability	-Positively impacted comfort, wellbeing & productivity.	-Positively impacted concentration.	-Improve perception of temporal and spatial pleasure
Presence of Water	-Enhanced perception & psychological responsiveness.	-Enhanced perception & psychological responsiveness.	Observed preferences and positive emotional responses
Dynamic & Diffuse Light	-Increase visual comfort. -Positively impacted circadian system functioning.		
Connection with Natural Systems			-Enhance positive health responses. -Shift perception of environment.
Natural Analogues Patterns			
Biomorphic Forms & Patterns			-Observed view preference
Material Connection With Nature		-Improve creative performance. -Decrease diastolic blood pressure.	-Improve comfort.
Complexity & Order	-Positively impacted perceptual & physiological stress responses.		-Observed view preference
Nature of the Space Patterns			
Prospect	Reduce stress	-Reduce stress, boredom, irritation & fatigue	-Improve comfort and perception of safety

Refuge	-Improved concentration, attention & perception of safety	
Mystery		-Induce strong pleasure response.

Source: Terrapin (2014).

2.3.1 Attention and restoration theory

The attention restoration theory (ART) is an example of a motivation theory, which helps to explain the reactions of humans, in particular, to the sensory information contained in their environment. Since each environment – interior or exterior – can contain any number of stimuli to which any or all of our senses can react, understanding the role of environmental effects on human functioning and wellbeing is vital to the successful application of any design plan (Gefen, 2004).

The Kaplans have hypothesized that "a preferred environment is thus more likely to be a restorative environment. Since nature plays such a powerful role in what is preferred, in general terms there is a theoretical basis for expecting natural environments to be restorative" (Kaplan & Kaplan, 2006). In order to better understand the qualities of restorative environments and for a setting to be a restorative, Kaplan & Kaplan (2006) determined that, the following components must exist: fascination, being away, compatibility and extent.

2.3.2 Recovery from stress or illness

Many studies have determined that leisure activities in natural settings or exposure to natural features have important stress reduction or restoration effects (Parsons et al., 1998; Ulrich, 1981). A frequently quoted study is that by Ulrich & Giplin (2003) who observed the effect of window view on recovery rate from gall bladder surgery.

Two sets of patients were matched on age, sex, weight, tobacco use, and previous hospitalization. The patients were divided into two types of recovery rooms:

The first room contained a picture of a natural scene of water and trees (Plate I), while the second room had abstract art, (Plate II).



Plate I: Natural scene image used in study.
Source: Ulrich & Giplin (2003).

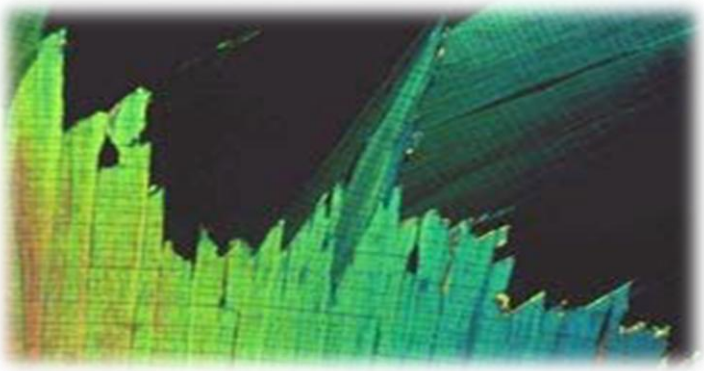


Plate II: Abstract picture used in study hospital room
Source: Ulrich & Giplin (2003).

The study results showed that those patients with the picture of natural view recovered faster than those in the other group (i.e. their post-operative hospital stays were shorter). Also, the natural view group patients had fewer negative comments in the nurses' notes and they had fewer injections of potent pain killers compared to those with the wall view.

2.3.3 Cognitive Functioning

Cognitive functioning includes our mental agility, memory, and our ability to think, learn and output either logically or creatively (Heerwagen & Mador 2009). For instance, directedattention is required for many tedious tasks, such as routine paperwork,reading and performing calculations or analysis, as well as for operating in highlystimulating environments, as when crossing busy streets.

There is also rising evidence of a strong link between nature and cognitive functioning. For instance, in a laboratory study by Virginia Lohr, subjects working in a windowless room with plants worked more efficiently, had lower blood pressure and felt more attentive than subjects working in the same room without plants. Even though the subjects' attention was focused on the computer screen and the plantings were arrayed around the perimeter of the room out of direct view, a positive impact was found.

2.4 The Biophilic Design

Biophilic design is an innovative approach to design that accentuates the importance of maintaining a connection with the natural world through the built environment (Kellert, 2005). It is familiar in buildings and landscapes that enhance human physical and mental well-being by fostering that positive connection through the design (Heerwagen, 2010). Although architects and developers are embracing this design approach today, it is, ironically, the way structures were built for much of human history.

To assist designers and developers in the practical application of biophilic design, Kellert (2008) has broken it down into two dimensions, six elements, and over 70 attributes in his chapter of *Biophilic Design: The Theory, Science, andPractice of Bringing Buildings to Life*.

2.4.1 Organic Dimension of Biophilic Design

The organic dimension of biophilic design is defined as shapes and forms which are found in the built environment that directly, indirectly, or symbolically reflect the inherent human affinity for nature (Kellert, 2005).

2.4.1.1 Direct connection with nature

Directattributesoforganicdesignresultinthefairlyinstant experience ofnaturein buildingsandconstructedlandscape. Naturallighting and natural ventilationarecommon expressionsofdirectorganicdesign(Kellert, 2005). Thesefeatures can betheresultof thoughtfuldesigndecisions,suchaslarge operablewindows, ortheresultoftechnicalinnovations,suchas chimney stacks, light shelves,andbuildingsoriented tothesunandprevailing winds (Takano, Nakamura, & Watanabe, 2002). A rich direct connection to nature within the built environment is shown as Plate III, an atrium in an office building for the Houses of Parliament in London designed by Hopkins Architects.



Plate III: Direct connections to nature afforded by natural light
Source: Kellert(2005).

2.4.1.2 Indirect Connections to Nature

Indirect connections to nature within the built environment are organized or manipulated contact with the natural environment that requires on standard human input to survive, such as a potted plant, a water fountain, natural materials, or an aquarium

(Kellert, Heerwagen & Mador, 2009). An example of an indirect connection to nature within the built environment is illustrated in Plate IV



Plate IV: The interior Frank Lloyd Wright's Falling water.
Source: Kellert(2005).

2.4.1.3 Symbolic Connections to Nature

Symbolic connections to nature within the built environment comprise no actual contact with real nature, but signify the natural environment through image, picture, ornamentation, video, metaphor, and other techniques (Kellert, Heerwagen & Mador, 2009). The symbolic expression of nature within the built environment can be experienced in both obvious and subtle ways.

An obvious expression of a symbolic connection to nature could be the application of a pattern utilizing organic shapes, and this is illustrated asPlate V.



Plate V: An obvious symbolic connection to nature.
Source: Bloomer (2015).

2.4.2 Vernacular Dimension of Biophilic Design

Acritical aspect ofrestorative environmental designis buildingsandconstructedlandscapes thatbondtotheplaceswheretheyoccur. Thisisreferredtoasvernaculardesign, which can be classified into four different types of vernacular dimensions of biophilic design. These include the following:

2.4.2.1 Vernacular Design Relating to Ecology of a Place

Effectivevernaculardesigninvolvesbuildingsandlandscapesthatareharmoniouswiththe ecologyoftheirplaceatthesite, ecosystem, andwatershedlevels.Achievingthiscompatibilityrequiresknowledgeofandsensitivity tovariousbiophysicalcharacteristics, including hydrology,soil,flora,fauna, atmosphere, andlandscape features(e.g.,wetlandsandotherdistinctiveecosystems) (Kellert, 2005).

2.4.2.2 Vernacular Design Relating to Culture and History of a Place

This is the vernacular design that connects to the culture of a place by creating spaces and reflects the architecture of its geographic region. It can create social traditions relating to place by encouraging traditions and shared relationships within these spaces (Kellert, 2005).

2.4.2.3 Vernacular Design in Relation to Culture and Ecology

When reinforced through the real vernacular design, the spirit of a place is neither a cultural nor an ecological phenomenon but rather the incorporation and creative fusion of the two (Kellert, 2005). The health and integrity of natural systems in human-dominated landscapes depend on positive connection between culture and nature (Kellert, 2005).

2.4.2.4 Vernacular Design Avoiding Placelessness

Unfortunately, modern architecture and land practices often degrade both culture and ecology and erode existing vernacular traditions. This phenomenon sometimes referred to as placeness, which is lessening the distinctive local and regional uniqueness and replacing it with uniformity and anonymity (Kellert, 2005).

One of the most successful and suitable examples of vernacular design is Renzo Piano's design for The Tjibaou Cultural Centre in New Caledonia (Plate VI). The Centre, which lies on a narrow band of land enclosed by water, features the ten 'cases' or curved maasstructures that rise from the ground all having altered heights and functions. The cases are constructed of wooden joists and ribs that quiver in the wind, and are meant to emulate the natural materials of the Melanesian huts.



Plate VI: Jean Marie Tjibaou Cultural Centre, New Caledonia
Source: Kellert (2005).

2.5 Biophilic Design Patterns

Nature is our guide to balance and harmony. Biophilia design patterns draw upon the distinctive intelligence found in nature, when plants turn their leaves to sun light, when a bird sit on egg and ultimately, when our body 'knows how to heal itself' (Kellert, 2002). The three pillar patterns serve as the dogmata of biophilic design –Nature in the space, Natural analogues, and Nature of the space–providinganoutlineforunderstanding and enablingconsiderateincorporation ofa richdiversityof strategies into thebuiltenvironment (Terrapin, 2014).

These patterns are extracted from the attributes of biophilia provided by Kellert, and were prove to a certain degree to have effects on human either physiologically, psychologically or on cognitive performance (see Table 2.1).

2.5.1 Nature in the Space

'Naturein theSpace'discoursesthedirect,physicalandephemeral presenceof natureinaspaceorplace (Terrapin, 2014). Thisincludesplant,waterandanimals,as well as breezes,sounds, scentsandothernatural elements (White, 2011). Common

examplesincludepottedplants,flowerbeds,birdfeeders,butterflygardens,waterfeatures, fountains,aquariums,courtyardgardens andgreenwallsorvegetatedroofs (Maas et. al., 2006).

Natureinthespace encompasses the followingbiophilic designpatterns:

2.5.1.1 Visual connection with nature

This is a viewtoelements ofnature, living systems andnaturalprocesses(Terrapin, 2014).It has been established from research on visual affection and responses to views to nature showing reduced stress, more positive emotional functioning and improved concentration and recovery rates (Chang & Chen, 2005). Anexample ofadesigned environmentwithanexcellentvisualConnectionwith natureisthebirchtreeandmossgardenin theNewTimesbuildinginNewYork City–acarvedoutspaceinthemiddleofthebuilding bywhich everyonepassesas theyenterorleavethebuilding (Plate VII).



Plate VII: New York times building.
Source: Flicker (2015).

2.5.1.2 Non-VisualConnectionwithNature

This is the auditory and haptic stimuli that arouse a thoughtful and positive reference to nature, living systems or natural processes (Terrapin, 2014). A space withagood non-visual connectionwithnaturefeels fresh and well balanced; theambientconditionsareperceived asintricateandvariablebutat thesame

timefamiliarandcomfortable, wherebysounds, aromas,andtextures arereminiscentofbeingoutdoors innature (Yamane et al., 2004).

Calat Alhambra in Granada, Spain, is an exquisite example of non-visual connection with nature (Plate VIII). The integration of water and natural ventilation with the architecture is central to the non-visual experience, supporting a seamless connection between indoor and outdoor spaces (Terrapin, 2014).



Plate VIII: A fountain & garden in the Calat Alhambra, Granada.
Source: Terrapin (2014).

2.5.1.3 Non-RhythmicSensory Stimuli

Stochastic andshort-livedconnections withnaturethatmaybeexaminedstatisticallybut maynotbeprojectedexactly (Terrapin, 2014). Aspace withgoodnon-rhythmicsensory stimulifeelsasi f oneisbriefly privy to something distinct, something fresh, interesting, inspiringand invigorating(Lewis,2012; Vessel, 2012).Itisabrief but a welcomedistraction.

2.5.1.4 Thermal & airflow variability

This is characterised as a subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments (Terrapin, 2014). Singapore's Khoo Teck Puat hospital is an excellent example of thermal airflow & variability. The passive design of the hospital allows the building

to draws fresh air form the exterior courtyards; the cool air helps maintain thermal comfort (Mitchell & Popham, 2008) (Plate IX).



Plate IX: Khoo Teck Puat Hospital, Singapore.
Source: Terrapin (2014).

2.5.1.5 Presence of Water

A situation that improves the experience of a place through seeing, hearing or touching of a water (Terrapin, 2014). The presence of water pattern has grew from research on visual preference for and positive emotional responses to environments containing eater elements; reduced stress and increased feelings of tranquillity (Pheasant et al., 2010). Robert and Arlene Kogod courtyard in the Smithsonian American art museum in Washington D.C., has seamless water sheets running across the floor, reflecting weather and lighting conditions and invites passer-by to touch (Plate X).



Plate X: Courtyard in Smithsonian American Art Museum, Washington DC.

Source: Terrapin(2015).

2.5.1.6 Dynamic and Diffuse Light

Varying intensities of light and shadow that changes over time to create conditions that occur in nature (Terrapin, 2014). Lighting conditions has long been used to set mood for a space, and different lighting conditions elicit differing psychological responses (Kendal et al., 2013). The objective for dynamic and diffuse light pattern is in two fold; to provide users with lighting conditions that stimulates eye in a manner that engenders positive psychological response, and to help maintain system functioning (Terrapin, 2014).

2.5.1.7 Connection with natural system

Awareness of natural processes, especially seasonal and temporal changes which are characteristics of a healthy ecosystem (Terrapin, 2014). Plate XI shows how the Cookfox Architects' office in New York dramatically changes appearance through the year, visually connecting occupants with the seasons and ecosystem activity.



Plate XI: CookFox Architects' New York Office through 4
Source: Terrapin(2014).

2.5.2 Natural Analogues

Natural analogues addresses organic, non-living and indirect elicitation of nature. Objects, materials, shapes, sequences and patterns found in nature, manifest in artwork, ornamentation, furniture, décor and textiles in the built environment (Terrapin, 2014). Mimicry of shells and leaves, furniture with organic shapes, and natural materials that have been processed or lengthy altered (e.g., wood planks, granite table tops), each provide an indirect connection with nature; while they are real, they are only an analogous of the items in their natural state (Vessel, 2012).

2.5.2.1 Biomorphic Forms&Patterns

Symbolic references to contoured, patterned, textured or numerical arrangements that persevere in nature (Terrapin, 2014). A space with good biomorphic forms & patterns feels interesting and comfortable, possibly captivating or even absorptive (Vessel, 2012). The art Nouveau hotel in Brussels is a favourite example of biomorphic forms &patterns. Theinteriorspace in particular isrife with naturalanalogues, with graphicvine-like tendrilspaintedonthewalland designedintothebanisters andrailings,floormosaics, window details,furniture, andcolumns (Plate XII).



Plate XII: Interior decorations of Tassel hotel in Brussels.
Source: Terrapin (2014)

2.5.2.2 MaterialConnectionwithNature

Materials and elements from nature that, through slight processing, replicate the local geology or ecology and create a different sense of a place (Terrapin, 2014). A space with a good material connection to nature feels rich, warm and true, and sometimes inspiring to the touch (Lichtenfeld et al., 2012). The objective of this pattern is to explore the characteristics and quantities of natural materials optimal for engendering positive cognitive or psychological responses.

2.5.2.3 Complexity &Order

Richsensualinformationthatfollowsaspatial hierarchysimilartothosemetinnature (Terrapin, 2014). A space with good complexity & order feels appealing and information-rich, as afascinating balance between boring and irresistible(Joye, 2007).The objective of this pattern is to provide regularities and fractal geometries, organized with a coherent spatial hierarchy, to create a visually beneficial environment that producespositive psychological or cognitive responses (Salingaros, 2012).

2.5.3 Nature of the Space

Nature of theSpaceaddressesspatialformationsinnature.Thisincludesour instinctiveandlearneddesiretobeabletoseebeyondourdirectsurroundings, our captivationwiththe slightlydangerousor unknown;coveredviewsand revelatory moments; and sometimes evenphobia-inducingproperties when theyincludeatrustedelement ofsafety (Terrapin, 2014).

NatureoftheSpace encompassesfourbiophilic designpatterns.

2.5.3.1 Prospect

Anunimpededviewoveradistance, for shadowingandplanning (Terrapin, 2014). A space with a good prospect condition feels open and freeing, yet imparts sense of safety and control, particularly when alone or in unaccustomed environments (Herzog & Bryce, 2007). Thecentral courtyard ofthe SalkInstituteforBiological Studies inCalifornia, designed by LouisKahn,is a popular example of a nearly pure Prospect condition (Plate XIII).



Plate XIII: The central Plaza of the Salk Institute
Source: Terrapin, (2014).

2.5.3.2 Refuge

of sanctuary and withdrawal – rest or healing (Grahn & Stigsdotter, 2010). A good refuge place also feels separate from its surrounding environment; its spatial characteristics feel contemplative embracing and protective, without unnecessarily disengaging (Hartig, 2003).

2.5.3.3 Mystery

Thepotentialofmoreinformation,achievedthroughpartially coveredviewsorothersensory devicesthatluretheindividualtotravel deeper into theenvironment (Terrapin. 2014). A space with a good mystery condition has a palpable sense of anticipation, or of being

teased, offering the sense of anticipation that compels one to further investigate the space (Kaplan & Bernat, 2010).ProspectPark,inBrooklyn,NewYork,isanexcellentexampleofmystery (Plate XIV). Inclassic Olmstedstyle, manyviewsthroughout the parkareobscuredthrough the use oftopography andvegetation. .

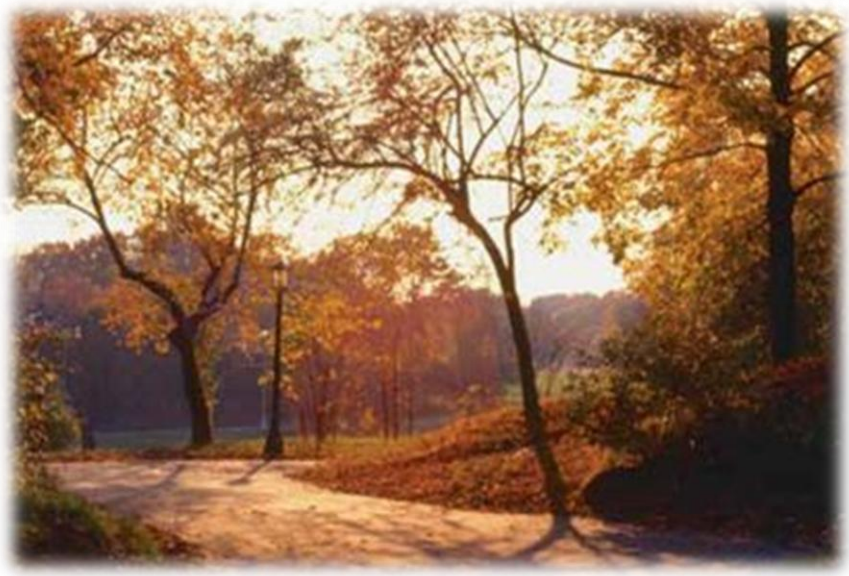


Plate XIV: Prospect Park in Brooklyn, New York
Source: Terrapin(2014).

2.5.3.4 Risk/Peril

A space with a good risk/peril condition feels exciting, and with an implied threat, maybe even little impish or perverse (Terrapin, 2014). One feels that it might be dangerous, but intriguing, worth exploring and possibly even irresistible.

2.6 Developing a Framework for the Integration of Biophilic Design Patterns

Building upon the work of Stephen Kellert (2008) on biophilic design principles, Terrapin (2014) came up with biophilic design patterns that articulate the relationship between nature, science and the built environment so as to experience the human benefits of biophilia in design applications. These biophilic design patterns focus on the

elements of nature-health relationship which are important in the built environment, especially those that are known to enhance human lives through a connection with nature.

However, the framework for the integration of these patterns into the built environment is underdeveloped. After a review of related literature on biophilic design, strategies were established on each pattern. These strategies paved a way of how the patterns can be incorporated in the built environment (Appendix I).

The result obtained from Appendix Iis further demonstrated in (Figure 1)to show the development of the framework for integration of these patterns in the built environment. Each category is colour coded and their relationship with one another is established. The biophilic architectural strategies of each pattern is highlighted to provide an easy insight of how each pattern can be realised in a built environment.This provides an analytic breakdown of how to incorporate nature in to the built environment.

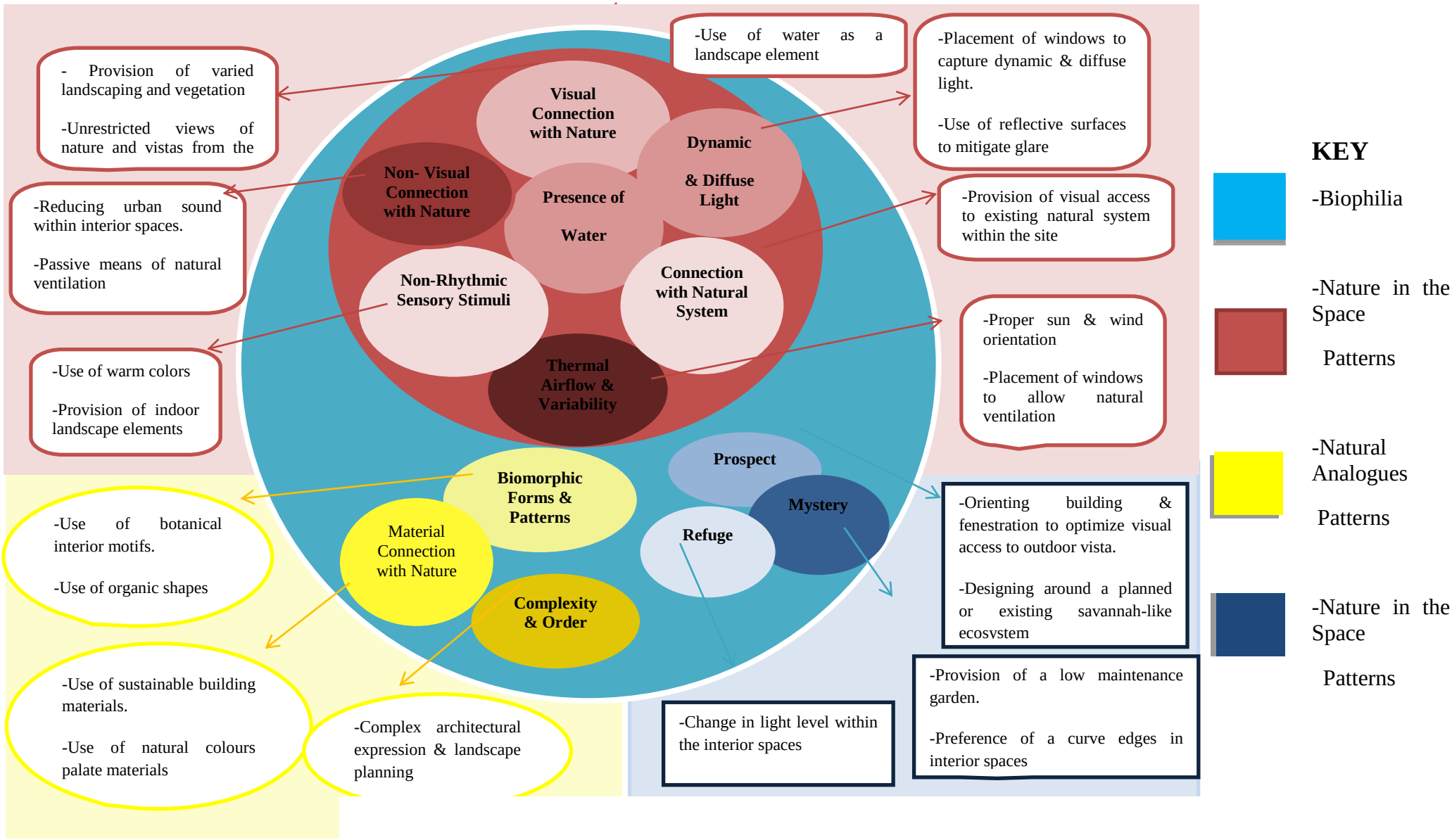


Figure 1: A framework for the integration of biophilic design patterns.

Source: Researcher's sketch (2015).

2.7 Cancer

Cancer is a group of diseases in which cells are aggressive (grow and divide without respect to normal limits), invasive (invade and destroy adjacent tissues), and sometimes metastatic (spread to other location in the body) (Smith, 2013). These three malignant properties of cancers differentiate them from being tumours, which are self-limited in their growth and don't invade or metasize (although some benign tumours type are capable of becoming malignant). Cancer may affect people at all ages, even foetus, but risk for the more common varieties tends to increase with age (Mistry et al., 2011).

2.7.1 Types of Cancer

Cancer is a large group of diseases (over 200) characterised by uncontrolled growth and spread of abnormal cells (American cancer society, 2005). However the most common types found in both male and female includes: prostate, liver, non-Hodgkin lymphoma, Kaposi sarcoma, colon & rectum, bladder, nasopharynx, oral cavity and leukaemia, breast, cervix uteri, ovary, Kaposi sarcoma, astrocytoma, rhomboid tumour, bone cancer, ewing sarcoma, and penile cancer, to mention but a few.

2.7.2 Treatment of Cancer

Cancer can be treated by surgery, chemotherapy, radiation therapy, immune-therapy, monoclonal antibody therapy or other methods (American Cancer Society, 2014). The choice of the therapy depends upon the location and grade of the malignant, stage of the disease as well as general state of the patient.

The control of the symptoms of cancer is not typically thought of as a treatment directed at cancer, it is an important determinant of the quality of life of the cancer patients. Most of these treatments have severe harsh side effects, which leave the cancer patients under a lot of physical and psychological duress (Rehse & Pukrop, 2003).

2.8 Relating Biophilic Design patterns & Biological Responses to Cancer and its Treatment

Psychological distress in cancer patients is a significant and on-going problem (Carlson, 2004).Emotional and psychological long-term side effects of cancer and its treatment include depression, anxiety, memory problems, and difficulty in concentration and reduced social skills (M.C.S., 2009).

Although a certain amount of emotional distress is common, particularly around the time of a diagnosis, approximately 50% of patients (150,000 people per year in U.K) experience levels of anxiety and depression severe enough to adversely affect their quality of life (N.I.C.E., 2004). Although psychological issues are more common in the first year after treatment, many patients continue to report significant levels of distress well after treatment has been completed (M.C.S., 2009).

Even 10 years on 54% of cancer survivors (over one million people alive in the UK) still suffer from at least one psychological issue (Thomas et. al., 2001). Some groups of cancer patients experience higher levels of distress. It is also not just cancer patients who suffer psychologically, significant percentage of carers experience anxiety and experience depression (Adler & Page, 2008).

A study of 199 cancer patients undergoing stem cell transplantation found that significant bouts of depression during hospitalisation predicted higher one and three year mortality, highlighting the importance of adequate diagnosis and treatment of depression. Neglecting psychological problems exacerbates illness and increases health care costs (Prieto, 2005).

Since biophilic design patterns have illustrious effect in humans by supporting stress reduction, cognitive performance, emotion and mood preference, it's the ideal treatment for the psychosocial problems associated with cancer and its treatment. Each individual

patterns of biophilic design support the biological relationship between health & design. It also provides anecdotal information which is compelling and adequate for hypothesizing its potential impact and importance as a unique pattern (Terrapin, 2014). Thus there is a strong relationship between the benefits provided by the biophilic design patterns and the mode ofcancer treatment. This relationship is demonstrated in Table 2.2 by creating biophilic response strategies resulted from relating biophilic design patterns and their biological responses with the psychological needs of the cancer patients.

Table 2.2: Biophilic response strategies

	Biophilic Patterns	Biological Responses	Biophilic Response Strategies in Architecture
		Nature in the Space Patterns	
1.	Visual connection with nature.	- Lowered blood pressure and heart rate. - Improve mental engagement/attentiveness. -Positively impacted attitude and overall happiness	- Provision of varied landscaping and vegetation -Unrestricted views of nature and vistas from the interior -Provision of healing gardens
2.	Non-visual connection with nature.	-Reduce systolic blood pressure. -Positively impacted cognitive performance. -Perceived improvements in mental health & tranquillity	-Access to nature sound over urban sounds -Integration of natural ventilation and presence of water
3.	Non-rhythmic sensory stimuli.	-Positively impacted heart rate and sympathetic nervous system activity.	-Use of warm colours for sensory stimulations -Provision of indoor landscape
4.	Thermal airflow & variability.	-Positively impacted comfort, wellbeing & productivity. -Positively impacted concentration. -Improve perception of temporal and spatial pleasure.	-Design with respect to sun and wind orientation -Placement of windows to allow natural ventilation
5.	Presence of water	-Enhanced perception & psychological responsiveness. -Reduce stress, increase feelings of tranquillity, lower heart rate.	-Use of water as a landscape element

6.	Dynamic & diffuse light	-Increase visual comfort. -Positively impacted circadian system functioning	-Placement of windows to capture dynamic and diffuse light within the interior of the building. -Use of reflective surface to enhance lighting and mitigates glare.
7.	Connection with natural system	-Enhance positive health responses. -Shift perception of environment	-Provision of visual to existing natural system within the site.
		Natural Analogues Patterns	
8.	Biomorphic forms & patterns	-Observed view preference	-Use of botanical interior motifs -Applications of organic shapes in building exterior
9.	Material connection with nature	-Decrease diastolic blood pressure. -Improve comfort. -Improve creative performance.	-Use of sustainable building materials. -Use of natural colour pallet like green within the interior spaces .
10.	Complexity & Order	-Positively impacted perceptual & physiological stress responses.	-Complex architectural expression and landscape planning.
		Nature of the Space Patterns	
11.	Prospect	-Reduce stress, boredom, irritation & fatigue -Improve comfort and perception of safety	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas -Designing around existing or planned savannah-like ecosystem.
12.	Refuge	-Improved concentration, attention & perception of safety	-Change in light levels within the interior.
13	Mystery	-Induce strong pleasure response.	-provision of low maintenance garden with winding path.

Source: Researcher (2016).

2.9 Literature Conclusion

The literature review provides important information that will be translated into the design application of this research work. Understanding the connection that humans have to the natural world through the biophilia hypothesis provides insight into the way we experience natural spaces. This will be considered when creating the design of cancerhospital and deciding what elements will be included and where. The knowledge gained from the portion of the literature related to cancer patients and their psychosocial needs will also play a large role in the design application. It is key for the design to be sensitive to the patients and to maintain it throughout.

3.0 CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this chapter is to present the research strategy and empirical techniques applied in order to appraise and explore ways in which biophilic design patterns have been integrated in the design & construction of existing cancer centres through case study approach. In this research, case studies will be conducted using qualitative and quantitative approach. Thus the research will employ the following methods of study;

3.2 Research Design

Research design refers to the methods, techniques, procedures and steps taken for data collection and analysis (Ngu, 2004). It is also a framework for the conduct of the research even before the data was collected; research design normally defends not only on the type of the research but also on the purpose of the research. As an exploratory research, this research work incorporates an emergent design, understanding develops and evolves through the research process and each data collection and analysis activity informs subsequent ones. This will be achieved through case studies and interview.

3.3 Case Studies

The theoretical assumptions underlying this research come from the qualitative tradition, which deals with interpretation of contemporary situation. The research strategy adopted was to conduct multiple case studies in different locations. A case study is an empirical enquiry that investigates a contemporary phenomenon in depth and within a real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Zainal, 2007). This documentation will be based

onevaluation of biophilic design patterns that allows incorporation of nature into the environment of a cancer hospital to reduce stress and produce a healing environment.

The assessment was carried out through visual surveys, and a checklist on the application of these outlined patterns of Biophilic design under study.

3.3.1 Population of study

For the purpose of research, a population is theoretically a specified aggregation of survey unit about which forms the basis of analysis and from which the samples are actually selected (Ngu, 2004). Population in this study will include cancer centres within the six geopolitical zones of Nigeria and few cancer centres outside of the country.

3.3.1 Sampling method/ case study selection criteria

A sample is a fraction of a population from which it is obtained. Case study selection is comparable to sampling in a quantitative research and that those cases are usually purposively selected (Veal, 2016 in Oluigbo, 2010). Therefore, the sampling technique chosen for this study is purposive sampling.

The case studies selected for this study would be sampled purposely to at least possess two among the following criteria.

I. As cancer center with adequate coverage in scope and facilities required to operate as a standard comprehensive cancer center.
II. As a facility that possesses some biophilic design patterns attributes.
III. As a facility that represents a certain region, so as to look at factors involving regional and technological diversities.

3.4 Data Collection

Case studies in Architecture begin with a documentation of the physical characteristics of the case, and for theoretical research they may be required the use of general methods of data collection (Oluigbo, 2010). However, the method of data collection adopted for this study isvisual survey and checklist, to assess the level of reflection of patterns of biophilic design on the cases studied and interview of patients & healthcare givers on the effect of biophilia as healing tool.

3.4.1 Instruments for data collection

For the purpose of this study, the instruments used for the collection and documentation of data arechecklist, photographs, sketches, and notes. Photographs were taken to capture relevant physical elements of the case studies to ascertain the extent or level of application of principles of biophilic design, planning, and construction. Sketches of some relevant part of the case study were necessary to further describe some features of spatial organization, or to enhance the quality of some details that are not too clear from the pictures taken during the field visit.

3.4.2 Procedures for data collection

The Procedures for data collection in the local case study holdnumerous techniques used for data collection in research, such as visiting some selected existing cancer centres at various pre-selected locations within the chosen geo-political zones, and taking visual analysis of their architectural elements as they reflect the biophilic design patterns under study. The numerousbuildings selected wereunfavourablyassessed based on the drawnstandards of analysis. The foreign case studies however were obtained from the internet and evaluated using the same measures as used for the local case studies.

3.5 Variables of the Study

The variables are those characteristics which the research sought to utilize as a unit of differential in the data collection process (Yin, 2004).On the level of reflection of biophilic design patterns, a checklist was employed to assess the extent of reflection of each pattern on the case studies (Appendix II). The variables which formed the checklist are:

i. **Nature in the Space:**
   - Visual connection with nature.
   - Non-visual connection with nature.
   - Non-rhythmic sensory stimuli.
   - Thermal airflow and variability.
   - Presence of water.
   - Dynamic & diffuse light.
   - Connection with natural systems.

ii. **Natural Analogues:**
   - Biomorphic forms & patterns.
   - Material connection with nature.
   - Complexity & order.

iii. **Nature of the Space:**
   - Prospect.
   - Refuge.
   - Mystery.

3.6 Data analysis and presentation

Analysis of data collected on the visual survey and observation is based on the descriptive accounts as observed, and noted via the instruments of data collection (Veal, 2006).

In order to achieve the research goal, the following instruments were used:

i. **Diagrammatic representation**: proper representation of data will be made by the use of sketches and also where drawings/ sketches will not do or are not available will be supported with pictures.

ii. **Figures:** the material obtained as illustrations on the biophilic design patternsobtained from books, the internet and the field survey of the case studies.

iii. **Tables:** comparison of information from case studies; and summary of findings were all done in tabular form for easement and accuracy.

iv. **Checklist:** a checklist will be prepared to capture extent of application of those biophilic design principles integrated in the existing cancer centres. A sample of the checklist is provided in Appendix I.

v. **Interview:** Interview was conducted to determine the nature and causes of psychological stress among cancer patients.

3.7 Site Selection Criteria

According to Kito & Thomas (2011), the following criteria will be considered in choosing the most desirable and effective site for the development of cancer center in F.C.T Abuja:

i. **Accessibility:** The site should easily be accessible through vehicular and pedestrian ways. Turning movement that creates conflict between vehicular and pedestrian ways should be avoided.

ii. **Land use compliance**: Current and projected zoning and land use should be compatible with the use of the site for a cancer hospital. This criterion will be evaluated according to difficulty and risk in changing the zoning or conditional use permit.

iii. **Biophilic significance**: Sites can be accessed for the biophilic quality of their surrounding such as presence of water body, vegetation, topography, views and surrounding.

iv. Access to services: Connection to existingand reliableservices like water and power supply with adequate capacity is considered. If a new services is required for the site, then sites should be rated as to their potential to support/provide the system.

v. Geographical zoning: The site should be located in a remote or silent parts of the city, so as to reduce access to urban noise.

vi. Ease for transporting of construction materials: proximity to transportation routes which can support heavy equipment and loads can affect the usability of a site for construction. Site closest to construction route will be most easily serviced.

vii. Site availability: The title of the site should be free of legal encumbrances, platted and surveyed with an accurate legal description.

viii. Distance from the city core: This will enable easy accessibility of the site from virtually all parts of the city and airports

ix. **Proximity for future expansion:** This criterion assesses long-range planning and land use factors related to hospital design in consideration of further expansion. Subjective evaluation of how well the site corresponds to future expansion will be considered.

4.0 CHAPTER FOUR: CASE STUDIES DESCRIPTION AND ANALYSIS

4.1 Introduction

The objective of the case study is to explore the ways in which biophilic design patterns has been integrated in the design and construction of existing cancer centres, so as to see how these patterns were used as a psychological therapeutic tools to meet the psychosocial needs of the patients.

The reflection of each pattern is ranked between one to four in a scale that represent absent-low-medium and high.

4.2 Case Study One: Oncology Department, National Hospital, Abuja.

The National Hospital, Abuja, established under Decree 36 of I996 (now, Act 36 of 1999), was commissioned on 22nd May 1999 by the former Head of State, General Abdusalam Abubakar, and opened its door to patients on 11th October 1999. The Hospital (Plate XV) was originally designed to cater for the needs of women and children in Nigeria and the west African sub-region with a view to reduce morbidity and mortality rate and to carry extensive research into the peculiar causes of women and children related diseases In Africa.



Plate XV: National Hospital Abuja, Nigeria.
Source: Author's fieldwork (2015).

4.2.1 Nature in the space variables

There are seven patterns under this category which are discussed below to check the level of their reflection in the oncology department, national hospital, Abuja.

4.2.1.1 Visual connection with nature

The hospital environment is adequately landscaped with indigenous vegetation through the creations of gardens around the hospital complex (Plate XVI). Due to the spatial design nature of the department coupled with moderate use of windows, there is relative access to outside vistas from the interior spaces.The oncology/nuclear department is a two storey structure adjacent to accident and emergency unit. Although there is provision of varied landscaping around the oncology department, there is no provision of healing garden in the facility.



Plate XVI: National Hospital Abuja, Nigeria.
Source: Author's fieldwork(2015).

4.2.1.2 Non-visual connection with nature

The oncology department is located away from the main roads so as to reduce noise pollution. The parking spaces are restricted to the front of the facility alone. This helps in reducing the prevalence urban sounds in the facility.

4.2.1.3 Non-rhythmic sensory stimuli

The oncology department is painted using shades of green and white to provide a warm feeling and helps in blending the facility with its natural environment (Plate XVII). There is relatively low provision of indoor landscaping within the facility.



Plate XVII: Warm paint of green and white.
Source: Author's fieldwork, (2015).

4.2.1.4 Thermal airflow and variability

Although the orientation of the hospital with respect to sun and wind is not optimize, the hospital draws fresh air through operable windows and courtyards provided (Plate XVIII)



Plate XVIII: A courtyard system.
Source: Author's fieldwork(2015).

4.2.1.5 Presence of water

The facility incorporates no water features, like fountains and aquarium, which will help in capitalizing on the multi-sensory attributes of water in a manner that is soothing to the patients.

4.2.1.6 Dynamic and diffuse light

The façade and the internal layout of the hospital are designed with adequate placement of windows to enhance daylighting and light/shade variability while reducing glares (see plate 4.5). Connecting, elevated exterior walkways also provide access to shade and reduce solar heat from reaching the interior spaces. But there is poor use of reflective surfaces to enhance daylighting.



Plate XIX: Placement of windows to capture dynamic light.
Source: Author's fieldwork, (2015).

4.2.1.7 Connection with natural system

Due to the spatial organisation of the hospital, there is little if not absence of visual connection with any natural system within the site.

4.2.1.8 Highlighting Nature in the Space patterns in National Hospital, Abuja

The above data is summarised in Table 4.1to capture the level of the reflection of biophilic patterns under 'nature in the space' category.

Table 4.1: Nature in the space description – Oncology department, National Hospital, Abuja, Nigeria

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Visual Connection With Nature	-Provision of varied landscaping and vegetation				x	2.7
	-Unrestricted views of nature and vistas from the interior	x				
	-Provision of healing gardens			x		
2. Non-Visual Connection With Nature	-Access to nature sound over urban sounds			x		2.5
	-Integration of natural ventilation and presence of water		x			
3. Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations			x		2.5
	-Provision of indoor landscape.		x			
4. Thermal Airflow & Variability	-Design with respect to sun and wind orientation		x			3
	-Placement of windows to allow natural ventilation				x	
5. Presence of Water	-Use of water as a landscape element	x				1
6. Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building			x		2.5
	-Use of reflective surface to enhance lighting and mitigates glare		x			
7. Connection With Natural System	-Provision of visual to existing natural system within the site		x			2
TOTAL						16
AVERAGE						2.3

Source: Author's fieldwork, (2015).

4.2.2 Natural analogues variables

The three patterns under this category are discussed below to check the level of their reflection in oncology department, national hospital, Abuja, Nigeria.

4.2.2.1 Biomorphic forms and patterns

The hospital doesn't incorporate botanical motif as interior design element. Also natural forms and shapes such as the organic shapes, arches, vaults and domes were not incorporated in the structure but there are columns supporting the projected covered walkways (Plate XX).



Plate XX: Extensive use of columns to support a covered walkway.

Source: Author's fieldwork(2015).

4.2.2.2 Material connection with nature

The architectural style of the facility is modern architecture with no sufficient evident use of sustainable building materials on the facility such as stabilized earth bricks and woods (Plate XXI). But the interior of the facility is painted with a warm colour of green to stimulate the feeling of comfort.



Plate XXI: Use of refined building material in the construction of the facility.
Source: Author's fieldwork(2015).

4.2.2.3 Complexity and order

The design of the facility is relatively simple but with repetitive order as symmetry. It also incorporates the use of domes (Plate XXII). More so, the extensive covered walkways network linked the various parts of the facility into a whole structure.



Plate XXII: A dome structure.
Source: Author's fieldwork(2015).

4.2.2.4 Highlighting Nature in the Space patterns in National Hospital, Abuja.

The scores of each variable is summarised in Table 4.2below;

Table 4.2: Natural analogues description – Oncology department, National Hospital, Abuja, Nigeria

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Biomorphic Forms & Patterns	-Use of botanical interior motifs	x				
	-Applications of organic shapes in building exterior		x			1.5
2. Material Connection With Nature	-Use of sustainable building materials		x			
	-Use of natural colour pallet like green within the interior spaces			x		2.5
3. **Complexity & Order**	-Complex architectural expression and landscape planning		x			
	-Integration of buildings parts into whole				x	3
TOTAL						7
AVERAGE						2.3

Source: Author's fieldwork(2015).

4.2.3 Nature of the space variables

The three patterns under this category are discussed below to assess the level of their reflection in national hospital, Abuja.

4.2.3.1 Prospect

The fenestration network of the facility is arranged surrounding the main structures so it can have a direct visual access to the surrounding landscape elements (Plate XXIII). Also the site is relatively flat and doesn't have any savannah like ecosystem.



Plate XXIII: Properly oriented walkway to optimise visual access to outdoor vistas.
Source: Author's fieldwork(2015).

4.2.3.2 Refuge

The diversity of interior spaces and different orientations of windows allows light to penetrate at variable levels within the interior of the facility, thus creating a sense of refuge.

4.2.3.3 Mystery

The hospital environment is rich with natural gardens that have obscured views which entice individual to travel more into the environment (Plate XXIV). Due to the cubic nature of the facility, there is no provision of curve edges anywhere in the interior spaces.



Plate XXIV: Gardens with obscured views that provide a sense of mystery.
Source: Author's fieldwork(2015).

4.2.3.4 Highlighting Nature in the Space patterns in National Hospital, Abuja

The level of reflection of these patterns is captured in Table 4.3 below;

Table 4.3: Nature of the Space description –National Hospital, Abuja, Nigeria.

Patterns Of Biophilic Design	Attributes	Level Of Reflection				Average
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas				x	2.5
	-Designing around existing or planned savannah-like ecosystem	x				
2. Refuge	-Change in light levels within the interior			x		3
3. **Mystery**	-Provision of low maintenance garden with winding path.			x		2
	-Preference of curve edges than sharp corners within the interior spaces.	x				
TOTAL						7.5
AVERAGE						2.5

Source: Author's fieldwork(2015).

4.2.4 Analysing biophilic design patterns in National Hospital, Abuja.

Taking total average scores of the patterns under each category shows that nature of the space have the score of 2.5, while natural analogues and nature in the space hasthe score of 2.3 each (seeTable 4.4 and Figure 2).

Table 4.4: Summary of findings in National hospital, Abuja

Biophilic Patterns (category)	**Score**
Nature in the Space	2.3
Natural Analogues	2.3
Nature of the Space	2.5

Source: Author's fieldwork(2015).

This result implies that the facility has better orientation and building exterior to optimise visual access to outdoor vistas while the extensive use of glazing, differing orientation of windows and provision of courtyards allow light to penetrate at varying levels within the interior spaces of the center which is a good demonstration of refuge. Although the score of 'natural analogues' is 2.3, still the center doesn't incorporate the use of botanical motifs in the interiors spaces and has no application of organic shapes in its exterior spaces. More so, the center has less use of sustainable building materials.

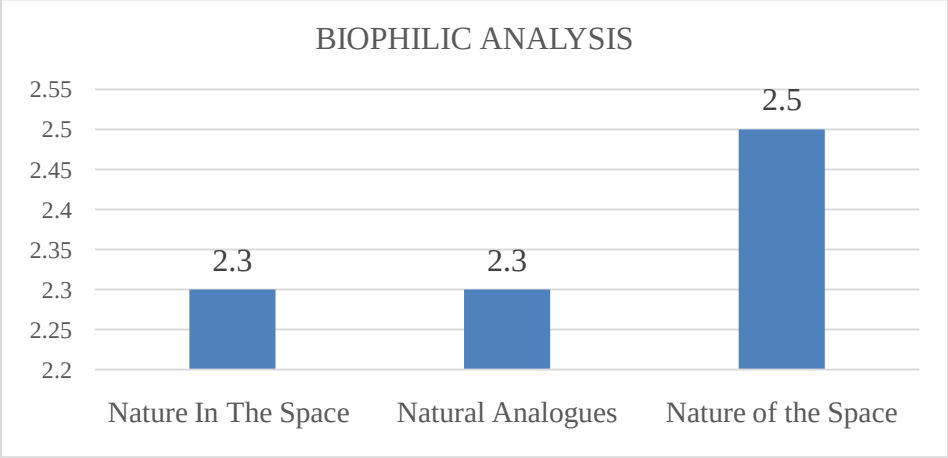


Figure 2: Biophilic analysis – Oncology department, National Hospital, Abuja.
Source: Author's fieldwork(2015).

4.3 Case Study Two: Oncology Center for Excellence, Ahmadu Bello University Teaching Hospital, Shika, Nigeria.

Ahmadu Bello University Teaching Hospital (ABUTH) Zaria started as Institute of Health in 1976 in accordance with statute 15 of the University (ABU) Law (amendment act, schedule 16) by the then interim Common services Agency (ICSA) of former Northern Nigeria Government (Plate XXV)..

The oncology department provide two basic treatments for cancer – radiotherapy and chemotherapy. The department started functioning in year 2000 and is referring to as centre of excellence in the treatment of cancer.



Plate XXV: Approach of ABUTH-Shika.
Source: Author's fieldwork (2015).

It has about 8 beds for chemotherapy. Apart from this, patients are accommodated in the general ward behind the administrative block. Average of 900 patients are treated in the department yearly. The chemotherapy section is adjacent to the radiotherapy treatment section at the ground floor to shield it off from the destructive effect of radiations. The two floors of the department houses the medical record, waiting area, wards, nurse station, the radiotherapy, head of department, consultants, seminar room, library, medical social workers.

4.3.1 Nature in the space variables

The seven patterns under this category are discussed below to check the level of their reflection in the oncology department, ABUTH-Shika.

4.3.1.1 Visual connection with nature

The environment surrounding department is rich in well planned landscaping and vegetation (Plate XXVI). More so, the spatial configuration of the hospital environment coupled with the strategic placement of windows makes it easy to have a direct visual access of outside views from the interior spaces. Although there is provision of varied

landscaping around the oncology department, there is absolutely no any healing garden provided for the patients.



Plate XXVI: Varied landscaping and vegetation.
Source: Author's fieldwork(2015).

4.3.1.2 Non-visual connection with nature

The department is located away from the main roads and parking spaces, and is surrounded with rich gardens. This significantly reduces the amount of urban sound reaching the department and provides more nature sound.

While there is absolutely zero use of water as a landscape feature, but adequate provision of windows provides natural ventilation within the facility.

4.31.3 Non-rhythmic sensory stimuli

There was presence of variety of colours present on the building interiors which blends the building to the immediate environment. Also, there is adequate provision of landscape plants within the corridors and interior spaces of the facility (Plate XXVII).



Plate XXVII: Interior landscape features.
Source: Author's fieldwork(2015).

4.3.1.4 Thermal airflow and variability

The orientation of the structure was placed with the longer axis almost facing north and south which is idle for the orientation of sun path and the prevailing winds. More so, there is extensive placement of windows to allow natural ventilation (Plate XXVIII).



Plate XXVIII: Adequate provision of windows.
Source: Author's fieldwork (2015).

4.3.1.5 Presence of water

The facility incorporates no water features, like fountains and aquarium, which will help in capitalizing on the multi-sensory attributes of water in a manner that is soothing to the patients.

4.3.1.6 Dynamic and diffuse light

The differing orientation of windows provided in the facility allows light to penetrate at variable levels of diffusion which created an enhanced patients experience (Plate XXIX). But there is low use of reflective surfaces which helps in mitigating glare.



Plate XXIX: Placement of windows in courtyard
Source: Author's fieldwork(2015).

4.3.1.7 Connection with natural system

There is no visual connection with any natural system within or outside the site.

4.3.1.8 Highlighting Nature in the Space patterns in ABUTH-Shika

The facility's level of reflection of Nature in the space variables are described in Table 4.5below.

Table 4.5: Nature in the Space description – Oncology department, ABUTH - Shika

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVE.
		Abs (1)	Low (2)	Med (3)	High (3	
1. Visual Connection With Nature	-Provision of varied landscaping and vegetation				x	1.5
	-Unrestricted views of nature and vistas from the interior	x		x		
2. Non-Visual Connection With Nature	-Access to nature sound over urban sounds			x		2.5
	-Integration of natural ventilation and presence of water		x			
3. Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations			x		3
	-Provision of indoor landscape.			x		
4. Thermal Airflow & Variability	-Design with respect to sun and wind orientation				x	3
	-Placement of windows to allow natural ventilation		x			
5. Presence of Water	-Use of water as a landscape element	x				1
6. Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building				x	3
	-Use of reflective surface to enhance lighting and mitigates glare		x			
7. Connection With Natural System	-Provision of visual to existing natural system within the site	x				1
TOTAL						**16**
AVERAGE						**2.3**

Source: Researcher's fieldwork (2016).

4.3.2 Natural analogues variables

The three patterns under this category are discussed below to check the level of their reflection in the oncology department, ABUTH-Shika.

4.3.2.1 Biomorphic forms and patterns

There is zero use of botanical motifs within the interior spaces and organic shapes like dome are absent on the facility's exterior.

4.3.2.3 Material connection with nature

No sufficient evident of sustainable building materials on the facility such as stabilized earth bricks and woods, but the interior of the facility is painted with a warm shade of green.

4.3.2.3 Complexity and order

The design of the structure employs symmetry with repetitive order, and the surrounding landscape is well planned. The extensive networks of covered walkways linked the various facilities together into a whole structure (Plate XXX).



Plate XXX: Walkways that connects building parts into whole.
Source: Author's fieldwork(2015).

4.3.2.4 Highlighting Natural Analogues patterns in ABUTH-Shika

The level of reflection of these patterns is captured in Table 4.5.

Table 4.5: Natural Analogues description – Oncology department, ABUTH – Shika, Nigeria.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Biomorphic Forms & Patterns	-Use of botanical interior motifs	x				2
	-Applications of organic shapes in building exterior	x				
2. Material Connection With Nature	-Use of sustainable building materials		x			2.5
	-Use of natural colour pallet like green within the interior spaces			x		
3. Complexity & Order	Complex architectural expression and landscape planning			x		3.5
	-Integration of buildings parts into whole				x	
TOTAL						8
AVERAGE						2.7

Source: Author's fieldwork, (2015).

4.3.3 Nature of the space variables

The three patterns under this category are discussed below to assess the level of their reflection in oncology department, ABUTH-Shika.

4.3.3.1 Prospect

The fenestration network of the facility is arranged surrounding the main structures so it can have a direct visual access to the surrounding landscape elements (Plate XXXI). The site is located in a valley-like environment. The hospital complex is designed to blend with the site terrain.



Plate XXXI: Fenestration network with visual access to outdoor vista.
Source: Author's fieldwork(2015).

4.3.3.2 Refuge

The diversity of interior spaces and different orientations of windows allows light to penetrate at variable levels to provide a sense of refuge within the interior spaces.

4.3.3.3 Mystery

The hospital environment is rich, low maintenance natural gardens provided near the facility through a courtyard system (Plate XXXII), while there is no provision of curve edges anywhere in the facility.



Plate XXXII: A low maintenance garden.
Source: Author's fieldwork (2015).

4.3.3.4 Highlighting Nature of the Space patterns in ABUTH-Shika, Nigeria.

The level of reflection of these patterns is captured in Table 4.6Below;

Table 4.6: Nature of the space description – Oncology department, ABUTH-Shika, Nigeria.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVE.
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas -Designing around existing or planned savannah-like ecosystem	x			x	2.5
2. Refuge	-Change in light levels within the interior			x		3
3. Mystery	-Provision of low maintenance garden. -Preference of curve edges than sharp corners within the interior spaces	x		x		2
TOTAL						7.5
AVERAGE						2.5

4.3.3 Analysing biophilic design patterns in ABUTH – Shika, Nigeria.

Taking total average scores of the patterns under each category shows that nature analogues have the score of 2.7, while nature in the space and nature of the space has2.7 and 2.5 respectively (see Table 4.7& Figure 3).

Table 4.7: Summary of findings in oncology department, ABUTH-Shika

Biophilic Patterns (category)	**Score**
Nature in the Space	2.3
Natural Analogues	2.7
Nature of the Space	2.5

Source: Author's fieldwork, (2015).

This result demonstrates that the facility has better demonstration of natural analogues patterns than the other two categories. This can be seen in complex architectural expression and landscape planning coupled with extensive use of walkways that connects different parts of the facility into a whole structure. More so, the use of paint with a natural colour pallet provides a sense of calm within the facility's interior spaces. Nature in the space variables has the least scores which can be attributed to the facility's poor design around an existing savannah- like ecosystem and no preference of curve edges than sharp corners within the interior.

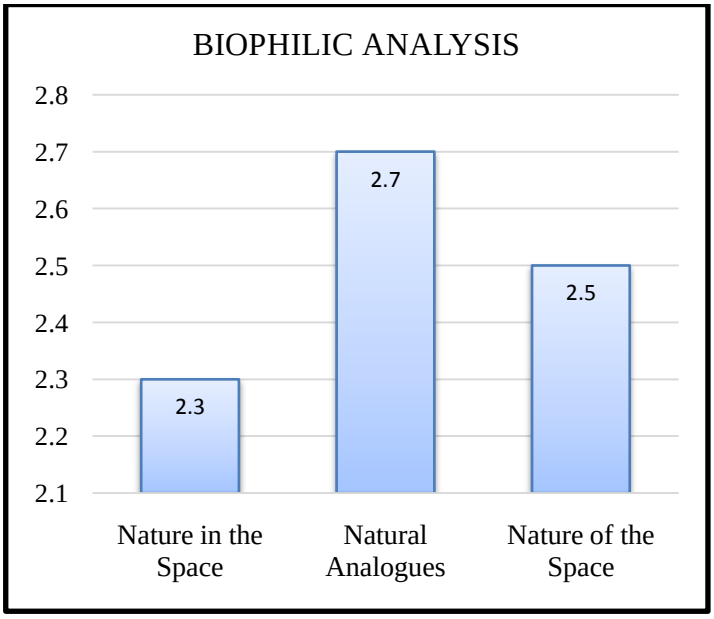


Figure 3: Biophilic analysis – Oncology department, ABUTH Shika

Source: Author's fieldwork (2015).

4.4Case Study Three: Frauenshuh Cancer Center, U.S.A

The Frauenshuh cancer center is a patient care facility located at park Nicolette Methodist hospital campus (Plate XXXVIII). The facility includes an advanced facility on a serene site that includes a healing garden, two acres of green space and over 250 new trees. Landform designed the site and provided landscape architecture services as a part a larger campus improvements project. In addition to the staff input during the design of the facility, three cancer survivors were involved throughout the design process.



Plate XXXIII: Approach of Frauenshuh Cancer Center.
Source: Nicollet (2015).

4.4.1 Nature in the space variables

The seven patterns under this category are discussed below to check the level of their reflection in Frauenshuh Cancer Center.

4.4.1.1 Visual connection with nature.

The area surrounding the main complex is fully integrated with varied landscaping and vegetation which created an oasis of calm in the hospital complex. There is provision of a healing garden which brings life and also gives patients hope and inspiration as they

journey through their transformational treatments (Plate XXXIV). Patients and staff have access to the healing aspects of the garden through various views from treatment rooms, hallways and waiting areas.



Plate XXXIV: A healing garden
Source: Nicollet(2015).

4.4.1.2 Non-visual connection with nature

The integration of water and natural ventilation in the design of the facility support the seamless connection between indoor and outdoor spaces within the facility, and between the building and the surrounding natural landscape. Thus, providing access to nature sound more than urban sound (Plate XXXV).



Plate XXXV: Exterior perspective of the facility.
Source: Nicollet, (2015).

4.4.1.3 Non-rhythmic sensory stimuli

The prevalent use of warm colours, inviting materials and indoor landscape elements in both public and treatment areas within the facility communicate a safe, healing environment for supporting patients' psychosocial needs such as anxiety and stress in an unfamiliar environment (Plate XXXVI).



Plate XXXVI: Interior landscape.
Source: Nicollet (2015).

4.4.1.4 Thermal airflow and variability

The passive design of the hospital draws air from the exterior environments; the cool air helps maintain thermal comfort, while patients also have large operable windows in their rooms allowing for greater personal control (Plate XXXVII).



Plate XXXVII: Placement of windows to capture dynamic & diffuse light.
Source:Nicollet (2015).

4.4.1.5 Presence of water

The extensive use of fountain within the facility creates a micro climate which helps in making the interior spaces both sounds and feels cooler (Plate XXXVIII).



Plate XXXVIII: A water fountain.
Source: Nicollet (2015).

4.4.1.6 Dynamic and diffuse light

Despite the building's stark exterior, the diversity of interior spaces and differing orientations of large windows allows light to penetrate at variable levels of diffusion to create an enhanced patients experience (Plate XXXIX).

The use of polished wooden flooring and reflective glasses enhance lighting and helps in mitigating glare within the facility's interior spaces



Plate XXXIX: Dynamic natural lighting within patients' ward.

Source: Nicollet (2015).

4.4.1.7 Connection with natural system

The extensive use of glazing makes it possible to see the surrounding landscape environment, which dramatically changes in appearance through the year, visually connecting people with the seasons and local ecosystem activity.

4.4.1.8 Highlighting Nature in the Space patterns in Frauenshuh Cancer Center, USA.

These variables are summarised in Table 4.8 to capture their level of reflection.

Table 4.8: Nature in the Space description – Frauenshuh cancer center, U.S.A.

PATTERNS OF BIOPHILIC DESIGN	**ATTRIBUTES**	**LEVEL OF REFLECTION**				**AVERAGE**
		Abs **(1)**	Low **(2)**	Med **(3)**	High **(4)**	
1. Visual Connection With Nature	-Provision of varied landscaping and vegetation			x		3.5
	-Unrestricted views of nature and vistas from the interior				x	
	-Provision of healing gardens				x	
2. Non-Visual Connection With Nature	-Access to nature sound over urban sounds				x	4
	-Integration of natural ventilation and presence of water				x	
3. Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations				x	4
	-Provision of indoor landscape.				x	
4. Thermal Airflow & Variability	-Design with respect to sun and wind orientation			x		3.5
	-Placement of windows to allow natural ventilation				x	
5. Presence Of Water	-Use of water as a landscape element				x	4

6. Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building -Use of reflective surface to enhance lighting and mitigates glare	x	x	3.5
7. Connection With Natural System	-Provision of visual to existing natural system within the site		x	4
TOTAL				25.5
AVERAGE				3.6

Source: Author's fieldwork(2015).

4.4.2 Natural analogues variables

The three patterns under this category are discussed below to check the level of their reflection in Frauenshuh cancer center.

4.4.2.1 Biomorphic forms and patterns

The hospital doesn't incorporate botanical motif as interior design element. Also natural forms and shapes such as the organic shapes, arches, vaults and domes were not incorporated in the structure.

4.4.2.2 Material connection with nature

The hospital wraps patients in an environment that the whole person – mind, body and spirit through the use of air quality and low emitting adhesives, paints, and composite wood products that might contain volatile organic compounds. The design also incorporates the zero use of building materials that usually contains carcinogenic materials. There is also extensive use of wood within the interior as an element of interior design (Plate XL).



Plate XL: A wooden interior finish
Source: Nicollet (2015).

4.4.2.3 Complexity and order

The design of Frauenshuh cancer center is made up of 3-storey building with small services buildings attached to the complex. The facility is a product of high-tech architecture with its plan made up of curve surfaces.

4.4.2.4 Highlighting Nature in the Space patterns in Frauenshuh Cancer Center, USA.

The above patterns under natural analogues are summarised in Table 4.9below to capture their level of reflection.

Table 4.9: Natural Analogues description – Frauenshuh cancer center. U.S.A.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Biomorphic Forms & Patterns	-Use of botanical interior motifs	x				1
	-Applications of organic shapes in building exterior	x				
2. Material Connection With Nature	-Use of sustainable building materials				x	3.5
	-Use of natural colour pallet like green within the interior spaces			x		
3. **Complexity & Order**	Complex architectural expression and landscape planning			x		3
	-Integration of buildings parts into whole			x		
TOTAL						7.5
AVERAGE						2.5

Source: Author's fieldwork (2015).

4.4.3 Nature of the space variables

The three patterns under this category are discussed below to assess the level of their reflection in Frauenshuh cancer center.

4.4.3.1 Prospect

The fenestration and the interior corridors facility is arranged in such a way that it can have a direct visual access to the surrounding landscape elements (Plate XLI). More so, the facility is designed to blend with natural ecosystem around it.



Plate XLI: Integration of landscape features around a fenestration
Source:Nicollet (2015).

4.4.3.2 Refuge

The facility features private treatment rooms and a dedicated chapel/meditation room which has wall photos and stories of cancer survivors to inspire hope and strength.

4.4.3.3 Mystery

The hospital environment is rich with natural gardens with obscured views that provide a sense of mystery. Due to the curve nature of the facility, there is avoidance of sharp corners within the interior spaces (Plate XLII).



Plate XLII: Exterior perspective of the facility
Source: Nicollet (2015).

4.4.3.4Highlighting Nature of the Space patterns in Frauenshuh Cancer Center, USA.

The three patterns under this category are captured inTable 4.10to show the level of their reflection in the case studied.

Table 4.10: Nature of the space variables – Frauenshuh cancer center, U.S.A.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs	Low	Med	High	
		(1)	**(2)**	**(3)**	**(4)**	
1. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas				x	4
	-Designing around existing or planned savannah-like ecosystem				x	
2. Refuge	-Spiritual spaces reserved for meditation & reflection.			x		3
3. Mystery	-Provision of low maintenance garden.				x	2.5
	-Preference of curve edges than sharp corners within the interior spaces			x		
Total						9.5
Average						2.3

Source: Author, (2015).

4.4.4 **Analysing biophilic design patterns in Frauenshuh Cancer Center, USA**.

Taking total average scores of the patterns under each category shows that nature IN the space have the score of 3.6, while natural analogues and nature of the space have 2.7 and 2.5 respectively (see table 4.11& Figure 4).

Table 4.11: Summary of findings in Frauenshuh cancer centre.

Biophilic Patterns (category)	**Score**
Nature in the Space	3.6
Natural Analogues	2.5
Nature of the Space	2.3

Source: Researcher (2015).

This result can be back up with adequate provision of nature in the space variables in the facility like presence of varied landscaping and vegetation, and most notably a healing garden.

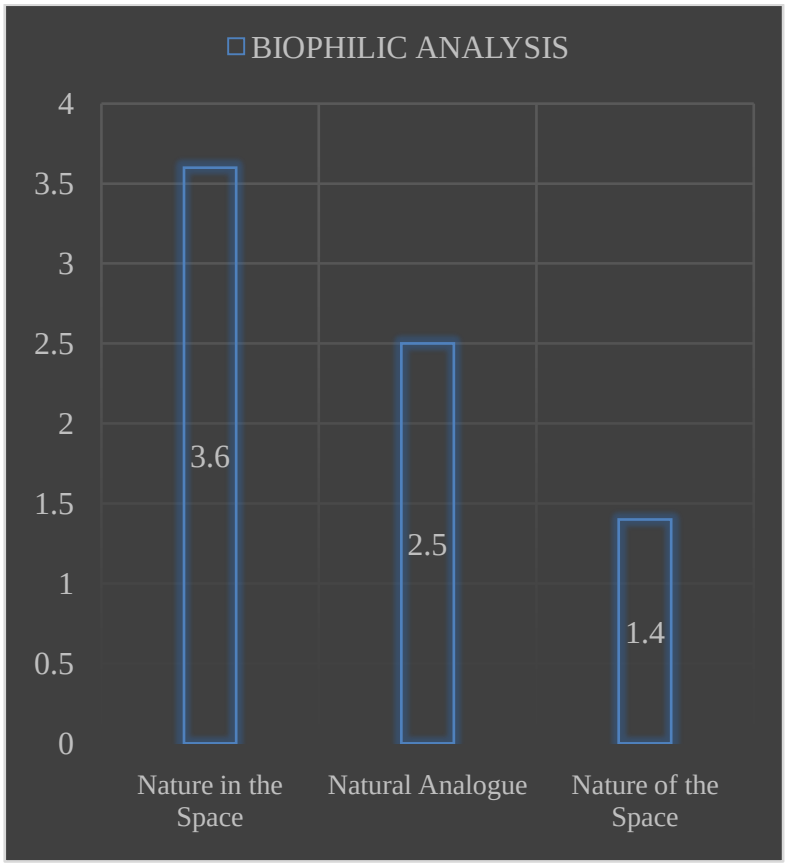


Figure 4: Biophilic analysis – Frauenshuh cancer center, USA.

Source: Researcher (2015).

4.5 Case Study Four: Windsor Regional Cancer Center, Ontario, Canada.

Located at the southwest edge of the Windsor Regional Hospital's Metropolitan campus, the building is sited to address the neighbouring residential streets and tree lined boulevards of Kildare Road and Alsace Avenue. The Windsor Regional Cancer Centre reflects a true collaboration among client, host hospital and design team. By addressing the client's vision for patient-focused care, the hospital's concern for facility programming and the design team's interest in integrating the building into the site, the team created an exemplary healthcare facility (Plate XLIII).



Plate XLIII: Approach of Windsor regional cancer center, Canada.
Source: Windsor, (2015).

4.5.1 Nature in the space variables

The seven patterns under this category are discussed below to check the level of their reflection in Windsor regional cancer center.

4.5.1.1 Visual connection with nature

The presence of several trees around the building helps to mitigate its scale, provide shade and make the new varied landscaping appear more mature. The whole facility is spatially planned with large exterior glazing to provide visual access with the outside vistas from the interior (Plate XLIV). There is also presence of healing gardens which helps in psychological calming effects on the patients.



Plate XLIV: Unrestricted view of outdoor vista from the interior spaces
Source: Windsor (2015).

4.5.1.2 Non-visual connection with nature

The use gardens within and outside the facility, coupled with presence water fountains create a microclimate within the facility. Also, solar heat penetrates at distinct locations within the facility and the whispering gallery of gardens resonate the sounds of nature.

4.5.1.3 Non-rhythmic sensory stimuli

The interior of the facility is partly finished with wood and limestone. Also, the interior is painted using paint and plaster in warm shade of ochre and green which further enhances the connection with the outdoor landscape (Plate XLV). There is also extensive use of indoor landscape found in the facility.



Plate XLV: Warm paint colours in interior spaces.
Source: Windsor (2015).

4.5.1.4 Thermal airflow and variability

The cool air from the exterior environments which as the result of the passive design of the facility helps in maintaining thermal comfort within the facility, while extensive provision of operable windows allows natural ventilation (Plate XLVI).



Plate XLVI: Array of windows used to allow natural ventilation.
Source: Windsor (2015).

4.5.1.5 Presence of water

A partially walled entry garden was constructed on the southern side of the building (Plate XLVII). The garden features a linear water garden that serves a calming space to visits or passes by when entering the facility.



Plate XLVII: A water fountain.
Source: Windsor (2015).

4.5.1.6 Dynamic and diffuse light

Multiple functions of the facility, extensive use of glazing and operable windows allows light to penetrate within the facility provides a calm backdrop to the visual scene within the interior spaces (Plate XLVIII).

The use polished wooden floors within the interior spaces allows little reflection of light.



Plate XLVIII: Use of glazing to capture dynamic and diffuse light
Source: Windsor (2015).

4.5.1.7 Connection with natural system

The facility is designed using grounded materials and projecting planes to achieve a very strong connection between the building and landscape. The influence of this exploration is evident in strong horizontal expression of projecting rooflines and elongated bricks.

4.5.1.8 *Highlighting Nature in the Space patterns in Windsor regional cancer center, Canada.*

The above patterns under nature in the space are summarised in Table 4.12 to capture their level of reflection.

Table 4.12: Nature in the Space description – Windsor regional cancer center, Ontario, Canada

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Visual Connection With Nature	-Provision of varied landscaping and vegetation			x		3.5
	-Unrestricted views of nature and vistas from the interior			x		
	-Provision of healing gardens				x	
2. Non-Visual Connection With Nature	-Access to nature sound over urban sounds			x		3
	-Integration of natural ventilation and presence of water			x		
3. Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations				x	4
	-Provision of indoor landscape.				x	
4. Thermal Airflow & Variability	-Design with respect to sun and wind orientation				x	3.5
	-Placement of windows to allow natural ventilation			x		
5. Presence Of Water	-Use of water as a landscape element				x	4
6. Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building				x	3
	-Use of reflective surface to enhance lighting and mitigates glare		x			
7. Connection With Natural System	-Provision of visual to existing natural system within the site			x		3
TOTAL						24
AVERAGE						3.4

Source: Author (2015).

4.5.2 Natural analogues variables

The three patterns under this category are discussed below to check the level of their reflection in Windsor regional cancer centre.

4.5.2.1 Biomorphic forms and patterns

There is zero use of botanical motifs within the interior spaces of the facility and very little application of organic shapes to its exterior.

4.5.2.2 Material connection with nature

The interior and exterior of the facility used material like pallet of red brick; limestone and a range of wooden finishes (Plate XLIX). Paint and plaster also in colours of ochre and green further enhance the connection with the outdoor landscape.

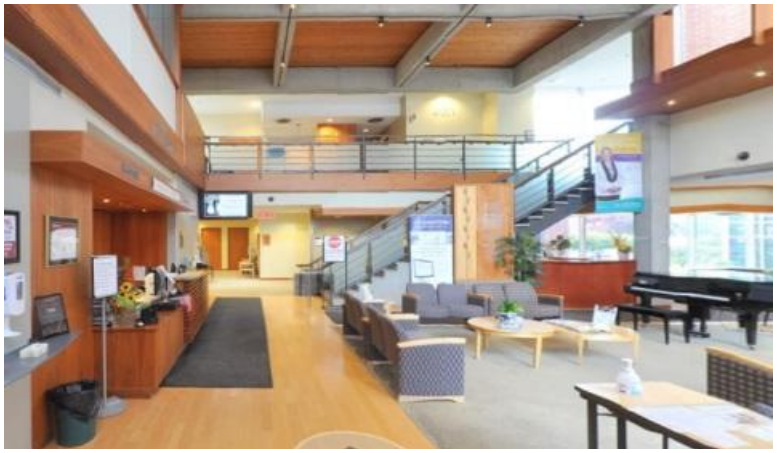


Plate XLIX: Use of wood and limestone in interior finishes.
Source: Windsor (2015).

4.5.2.3 Complexity and order

Although there is complex landscape planning in the facility, its architectural expression is simple comprising of two storey main lobby which acts as a spatial hub offering access to the centre's various facilities. A ramp along the western edge of the lobby leads patients and visitors down to the radiation treatment area.

4.5.2.4 Highlighting Natural Analogues patterns in Windsor regional cancer center, Canada.

The above patterns under natural analogues are summarised in Table 4.13to capture their level of reflection.

Table 4.13: Natural Analogues description – Windsor regional cancer center, Ontario, Canada

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Biomorphic Forms & Patterns	-Use of botanical interior motifs	x				1.5
	-Applications of organic shapes in building exterior		x			
2. Material Connection With Nature	-Use of sustainable building materials				x	4
	-Use of natural colour pallet like green within the interior spaces				x	
3.Complexity & Order	Complex architectural expression and landscape planning		x			2.5
	-Integration of buildings parts into whole			x		
TOTAL						8
AVERAGE						2.7

4.5.3 Nature of the space variables

The three patterns under this category are discussed below to assess the level of their reflection in Windsor regional cancer centre.

4.5.3.1 Prospect

The corridors of the facility are designed with extensive visual access to exterior landscape (Plate L). But there is little correlation between the facility and the existing ecosystem around the site.



Plate L: Landscape elements designed around a fenestration network
Source: Windsor (2015).

4.5.3.2 Refuge

Due to the stark nature of the facility couples differing orientations of glazing allows light to penetrate at varying degrees thus creating change in light levels within the interior of the facility.

4.5.3.3 Mystery

There are gardens along south entry façade and west façade that serves not only in providing interesting views but also greatly assist patients in way finding Due to the spatial arrangement of the facility, the interior spaces adopt sharp corners.

4.5.3.4 Highlighting Nature of the Space patterns in Windsor regional cancer center, Canada.

The above patterns under nature of the space are summarised in Table 4.14to capture their level of reflection.

Table 4.14: Nature of the space description– Windsor regional cancer center, Ontario, Canada.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs	Low	Med	High	
		(1)	**(2)**	**(3)**	**(4)**	
1. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas			x		2.5
	-Designing around existing or planned savannah-like ecosystem		x			
2. Refuge	-Change in light levels within the interior			x		3
3. Mystery	-Provision of low maintenance garden.			x		2
	-Preference of curve edges than sharp corners within the interior spaces	x				
Total						7.5
Average						2.5

Source: Author, (2015)

4.5.4 Analysing biophilic design patterns in Windsor regional cancer center, Canada.

Taking total average scores of the patterns under each category shows that nature in the space have the score of 3.6, while natural analogues and nature of the space has 2.7 and 2.5 respectively (**Error! Reference source not found.**16& Figure 4.4).

Table 4.15: Summary of findings in Windsor regional cancer center

Biophilic Patterns (category)	**Score**
Nature in the Space	3.6
Natural Analogues	2.7
Nature of the Space	2.5

Source: Author, (2015).

This result demonstrates that the facility have better utilization of the patterns under nature of the space. It can be seen in the good visual access to nature as the result of extensive glazing provided. More so, the use of sustainable building materials like wood and limestone coupled with provision of fountains help in creating a friendly environment for the patients and staff.

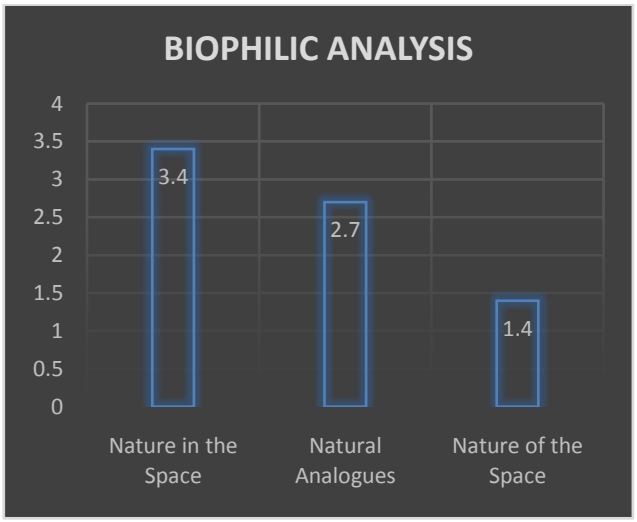


Figure 5: Biophilic analysis – Windsor regional cancer center, Ontario, Canada
Source: Researcher (2015).

4.6 Case Study Five: Helen F Graham Center, Delaware, USA.

Located on the Christiana Hospital campus, the beautifully designed and landscaped, 200,000-square-foot Helen F. Graham Cancer Center is a state-of-the-art facility that serves a majority of the cancer patients residing in Delaware (Plate LI). This National Cancer Institute selected Community Cancer Center features advanced medical, surgical and radiation procedures and diagnostic services.



Plate LI: Entrance of Helen F Graham cancer center.
Source: Helen (2015).

4.6.1 Nature in the space variables

The seven patterns under this category are discussed below to check the level of their reflection in Helen F Graham cancer centre.

4.6.1.1 Visual connection with nature

Landscape of the site was predominantly naturally growing grasses, abundant trees and existing pond which provide areas for shading and relaxation. The building stark exterior is extensively glazed and oriented to provide visual access to outdoor vistas and existing pond. There is also specially planned healing garden dedicated to the patients which is located adjacent to their wards so it can be accessed easily(Plate LII).



Plate LII: A healing garden.
Source: Helen (2015).

4.6.1.2 Non-visual connection with nature

The facility is located at the northwest corner of the Christiana care facility, with an existing pond serving as barrier between urban environment and the biophilic environment around the site. This contributes usefully in isolating the facility from the urban noise of Delaware. The existing pond, water fountains coupled with large operable windows provides natural ventilation within the facility thereby creating a pleasant micro climate (Plate LIII).



Plate LIII: A water garden.
Source: Helen (2015).

4.6.1.3 Non-rhythmic sensory stimuli

The interior of the facility is painted with warm colour of yellow and finished with wooden panels for sensory stimulations (Plate LIV). More so, there is adequate provision of interior landscaping elements like fountains and plants.



Plate LIV: Use of warm colours in interior spaces
Source: Helen (2015).

4.6.1.4 Thermal airflow and variability

The facility is well oriented with respect to sun and wind path. Also the passive design of the hospital draws air from the exterior environments; the cool air helps maintain thermal comfort, while there is also provision of large operable windows allowing a greater personal control (Plate LV).



Plate LV: Extensive use of operable windows to allow natural ventilation.
Source: Helen (2015).

4.6.1.5 Presence of water

The facility is designed to integrate an existing pond within the site. There is also extensive use of beautiful water features such as fountains within and around the facility (Plate LVI).



Plate LVI: A water fountain.
Source: Helen (2015).

4.6.1.6 Dynamic and diffuse light

Although the building's exterior is stark, the curve of interior spaces, provision of courtyards and differing orientations of large windows allows light to penetrate at variable levels of diffusion to create an enhanced patients experience.

The use of polished ceramic flooring and reflective glasses enhance lighting and helps in mitigating glare within the facility's interior spaces (Plate LVII).



Plate LVII: Dynamic natural light within the interior spaces
Source: Helen (2015).

4.6.1.7 Connection with natural system

The facility is designed around an existing pond on the site (Plate LVIII). The curve nature of the building and extensive glazing on the exterior provide a visual access to the pond and its seasonal changes.



Plate LVIII: An existing pond around the facility.
Source: Helen (2015).

4.6.1.8 Highlighting Nature of the Space patterns in Helen F Graham cancer center, USA.

The above patterns under nature in the space are highlighted in Table 4.16to capture their level of reflection.

Table 4.16: Nature in the Space description - Helen F Graham cancer center. Delaware, USA.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Visual Connection With Nature	-Provision of varied landscaping and vegetation				x	4
	-Unrestricted views of nature and vistas from the interior				x	
	-Provision of healing gardens				x	
2. Non-Visual Connection With Nature	-Access to nature sound over urban sounds			x		3.5
	-Integration of natural ventilation and presence of water				x	
3. Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations			x		3
	-Provision of indoor landscape.			x		
4. Thermal Airflow & Variability	-Design with respect to sun and wind orientation			x		3.5
	-Placement of windows to allow natural ventilation				x	
5. Presence Of Water	-Use of water as a landscape element				x	4
6. Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building				x	3.5
	-Use of reflective surface to enhance lighting and mitigates glare			x		
7. Connection With Natural System	-Provision of visual to existing natural system within the site				x	4
Total						26.5
Average						3.8

Source: Author(2015).

4.6.2 Natural analogues variables

The three patterns under this category are discussed below to check the level of their reflection in Helen F Graham cancer center.

4.6.2.1 Biomorphic forms and patterns

There is no evidence of incorporation of botanical motifs within the interior spaces of the facility, and natural forms and shapes such as the organic shapes, arches, vaults and domes were not incorporated in the structure but the design of the inverted t-shaped beams was a great architectural expression.

4.6.2.2 Material connection with nature

There is extensive use of compressed earth brick and wooden finishes in the facility (Plate LIX). Also recyclable materials were used. The interior is painted with a warm colour of yellow to provide a calming effect.



Plate LIX: Use of wooden interior finishes
Source: Helen (2015).

4.6.2.3 Complexity and order

The facility is simply design with a curve nature so as to follow the pattern of the existing pond. It incorporates principles of high-tech architecture with the extensive use of glass and steel.

The functions of the facility are arranged on 4 floors but interconnected with staircases and hallways so as to provide a seamless care to patient.

4.6.2.4 Highlighting Nature Analogues patterns in Helen F Graham cancer center, USA

The above patterns under natural analogues are summarised in Table 4.17to capture their level of reflection.

Table 4.17: Natural Analogues description – Helen F Graham cancer center. Delaware, USA.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs	Low	Med	High	
		(1)	**(2)**	**(3)**	**(4)**	
1. Biomorphic Forms & Patterns	-Use of botanical interior motifs		x			2
	-Applications of organic shapes in building exterior		x			
2. Material Connection With Nature	-Use of sustainable building materials				x	4
	-Use of natural colour pallet like green within the interior spaces				x	
3. **Complexity & Order**	Complex architectural expression and landscape planning			x		3
	-Integration of buildings parts into whole			x		
Total						9
Average						3

Source: Author(2015).

4.6.3 Nature of the space variables

The three patterns under this category are discussed below to check the level of their reflection in the case studied.

4.6.3.1 Prospect

The fenestration and the interior corridors of the facility are arranged in such a way that it have a direct visual access to the surrounding landscape elements (Plate LX). More so, the facility is designed to blend with the existing pond in the site, thus creating powerful water architecture.



Plate LX: Proper orientation of the facility to optimise visual access
Source: Helen (2015).

4.6.3.2 Refuge

The differing orientations of glazing and use of courtyards allows light to penetrate at varying degrees within the facility thus creating change in light levels within the facility.

4.6.3.3 Mystery

The existing pond on the site contributes immensely in providing low maintenance natural gardens around the facility (Plate LXI). The building is cubic in nature, and interior spaces adopts sharp right-angles corners.



Plate LXI: A low maintenance garden around existing pond
Source: Helen (2015).

The above patterns under nature in the space are summarised in table 4.18 to capture their level of reflection.

Table 4.18: Nature of the space description– Helen F Graham cancer center, USA.

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				AVERAGE
		Abs (1)	Low (2)	Med (3)	High (4)	
1. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas			x		3.5
	-Designing around existing or planned savannah-like ecosystem				x	
2. Refuge	-Change in light levels within the interior			x		3
3. Mystery	-Provision of low maintenance garden.				x	2.5
	-Preference of curve edges than sharp corners within the interior spaces	x				
Total						9
Average						3

Source: Author (2015).

4.6.4 Analysing biophilic design patterns in Helen F Graham cancer center, USA.

Taking total average scores of the patterns under each category shows that nature of the space have the score of 3.8, while natural analogues and nature in the space has the score of 3 each (Table 4.19& Figure 6).

Table 4.19: Summary of findings in Windsor regional cancer center

Biophilic Patterns (category)	**Score**
Nature in the Space	3.8
Natural Analogues	3
Nature of the Space	3

Source: Author (2015).

Computing the results in table 4.20 shows that nature in the space has 39%, while natural analogues and nature of the space have 29% and 32% respectively (seeFigure6). This result demonstrates that the facility have least scores under natural analogues patterns, and it can be as the result of rectangular nature of the facility that provided sharp corners within the interior spaces. More so, the sense of prospect and refuge within the facility is relatively average.

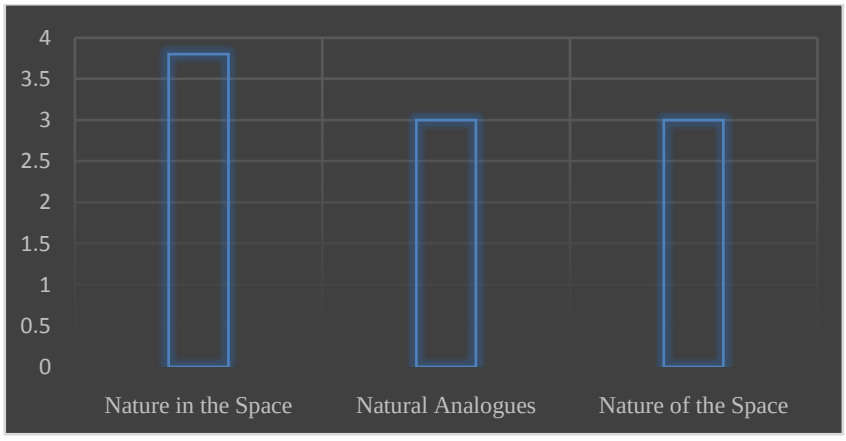


Figure6: Biophilic Analysis – Helen F Graham Cancer Centre.
Source: Source: Researcher (2015).

4.7 Biophilic Analysis in all the Cases Studied

The results obtained from all the cases studied is summarised using the average scores of each pattern inTable 4.20This section deals with the biophilic analysis to find out the reflection of patterns under study and discussion on the findings of the cases studied. Average scores were taken so as to be able to compare and analyse the performance of the categories of biophilic patterns against each other, thereby exploring how they were adopted in all the cases studied and how they will subsequently be adapted in the design of a new biophilic cancer centre.

Table 4.20: Case studies summary of findings.

NAME	LOCATION	BIOPHILIC DESIGN PATTERNS (Level of Reflection)			**TOTAL**
		Nature in the Space	Natural Analogues	Nature of the Space	
1. Oncology Center, National Hospital, Abuja.	Local	2.3	2.3	2.5	7.1
2. Oncology Center for excellence, ABUTH-Shika	Local	2.3	2.7	2.5	7.5
3. Frauenshuh cancer center	International	3.6	2.5	2.3	8.4
4. Windsor regional cancer	International	3.4	2.7	2.7	8.8
5. **Helen F Graham cancer center**	International	3.8	3	3	9.8
TOTAL		15.2	10.5	13	
AVERAGE		3.1	2.1	2.6	

Source: Author(2015).

Taking total average scores of each category from table 4.21 and computing them in a bar chart (Figure 7) shows that in all the cases studied, Nature in the space patterns has the highest score of 3.1, while Nature of the space patterns and Natural analogues patterns have the score 2.6 and 2.1respectively.

The result demonstrate that nature in the space patterns are more favoured in the design of a health care setting which provides spaces that promotes healing and ease psychological stress. These patterns are evident in most of the cases studied through the provision of varied landscaping and vegetation, utilisation of unrestricted view of vistas from the interior spaces and presence of healing gardens. More so, there is use of warm colours within the interior spaces for sensory stimuli and proper design of the facilities with respect to sun and wind orientation. Conclusively, most of the facilities used water as a landscape feature, incorporates extensive use of glazing to provide visual access to the existing system and provide natural ventilation within the facility.

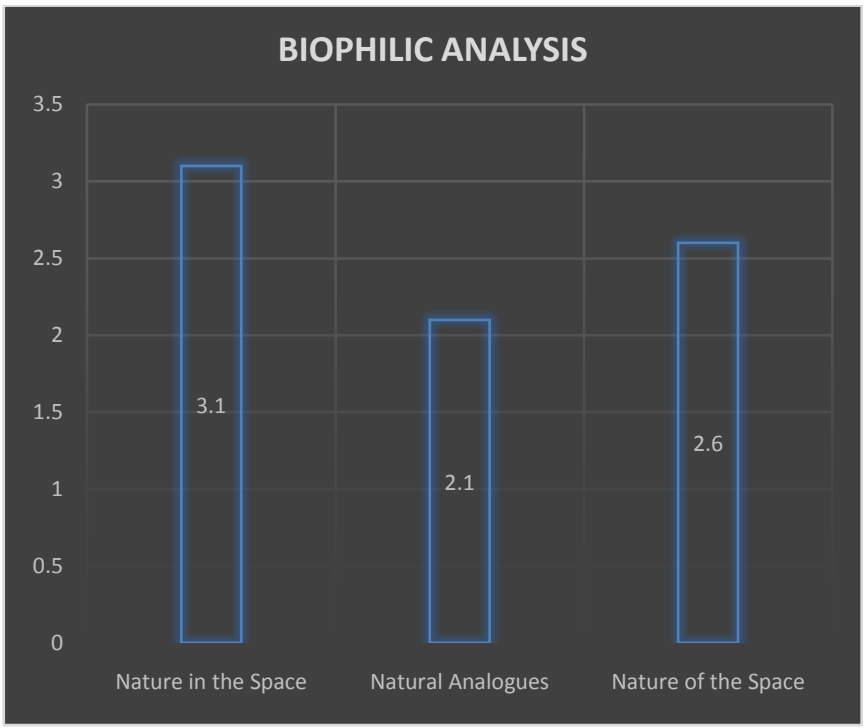


Figure 7: Biophilic analysis in all the cases studied

Source: Author(2015).

Although the nature of the space patterns is 0.5 greater than the score of natural analogues patterns (see figure 4.6), most of the cases studied have low maintenance garden around their facilities, better orientation of fenestration and building exterior to optimise visual access to outdoor vistas, and design around existing or planned savannah. More so, the use of extensive glazing, differing orientation of windows and provisions of courtyard within most of the cases studied allow light to penetrate at varying levels within their interiors spaces thereby creating a sense of refuge.

Natural analogues patterns have the least score of 2.1, which can be attributed to the inadequate incorporation of botanical motifs within the interiors spaces in most of the cases studied. More so, the usage of simple landscape planning and architectural expression, poor use of sustainable building materials and use of unnatural colours within the interior spaces contributes immensely to the poor performance of these patterns in the cases studied.

4.8 Summary of Findings

The major of findings made from the cases studied are summarized below;

4.8.1 Visual connection with nature

All the cases studied were spatially planned to have visual connection with the existing varied landscaping and vegetation. Only the international cases studied have provision of healing gardens designed for the patients.

4.8.2 Non-visual connection with nature

Local cases studied strategically placed their parking facilities away from the facilities to reduce urban sound, while international cases used the integration of water and natural ventilation in their design to support the seamless connection between indoor and outdoor spaces.

4.8.3 Non-rhythmic sensory stimuli

The local cases studied generally have poor incorporation of natural colours in their design. The international cases studied have their interior spaces painted with warm shades of colours and wooden finishes which further enhances the connection of those facilities with their exterior environment.

4.8.4 Thermal airflow & variability

All the cases studied used passive means of lighting and ventilation by providing cross ventilation through the use of large operable windows and some cases studied employed the use of courtyard system.

4.8.5 Presence of water

The use of water as a landscape element was only adopted in the international case studies.

4.8.6 Dynamic & diffuse light

The local cases studied use verandas and covered walkways to direct solar radiations within the interiors, while the international cases studied employed large glazing to achieve the same.

4.8.7 Connection with natural system

The local cases studied has little if not absence of any connection with natural system around their sites, as against the international cases which were designed to blend with their immediate environments.

4.8.8 Biomorphic forms & patterns

All the cases studied do not incorporate botanical motifs within their interior. Moreover, the local cases studied have zero use of organic shapes, while their international counterparts have little reflection of the shapes.

4.8.9 Material connection with nature

The materials used in construction of the local case studies from fabric to finishes were mostly refined materials (mostly concrete, glass and aluminium) which requires great energy in their production, as against most of the international case studies that employed the use of sustainable building materials (like wood and locally quarried limestone) which are low impact on the environment and are organic in nature.

4.8.10 Complexity & Order

Only Frauenshuh cancer center and Helen F Graham cancer employs curve forms in their design, while the building forms of the rest were generally rectilinear with perfect straight lines and sharp edges.

4.8.11 Prospect

The fenestration and the interior corridors of tall the cases studied were arranged in such a way that they have a direct visual access to the surrounding landscape elements.

4.8.12 Refuge

The Architectural styles of the cases studied are all modern style as against vernacular style which is one of the major components of biophilic design.

4.8.13 Mystery

All the cases studied have low maintenance gardens. Most of international cases use curve design to avoid sharp corner edges within their interior spaces.

4.9 Survey on Psychosocial Aspect in Cancer Patients

Oral interview was conducted to obtain the perceptual orientation of users (patients & healthcare givers) with respect to creating restorative/healing environment.

4.9.1 DistributionofPsychologicalDepressionsofCancer Patients

Nature and extent of various psychosocial effects among cancer patients was determined using oral interview in both controlled and experimental groups (Appendix III).

4.9.2 DistributionofhobbyofCancer Patients

Type of hobbies among cancer patients was determined using oral interview in both controlled and experimental groups (Appendix IV).

4.9.3 CausesofPsychologicalDepressionsamongCancer Patients

Causes of psychological depression among cancer patients was determined using oral interview in both controlled and experimental groups (Appendix V).

5.0 CHAPTER FIVE: STUDY AREA

5.1 Introduction

This chapter reports the conceptual and analytical ways employed through design process for choosing site and subsequently analysing it to suite the need of the design. The discussion will be under the following major subheadings: Study area profile, site selection criteria, site analysis and effects of environmental and climatic factors on building design.

5.2 Study Area Profile

Abuja is the capital city of Nigeria. It islocated in the centre of Nigeria, within the FederalCapital Territory (FCT). It covers a geographical area of about 2,824 square miles (7,315 square km) and falls within latitude 7° 25' N and 9° 20° north of the Equator and longitude 5° 45'E and 7° 39'E (Figure 8).

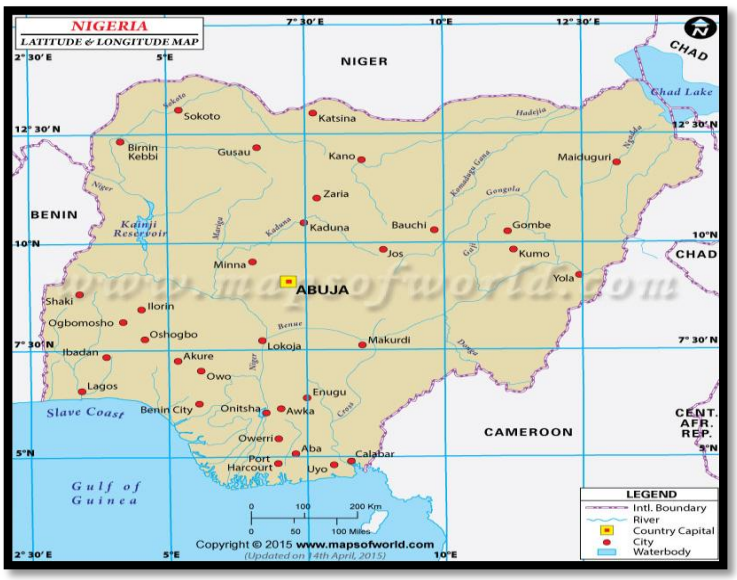


Figure 8: Geographical coordinates of Abuja.

Source: Google Images(2015).

Abuja is a planned city, andwas built mainly in the 1980s. It officially becameNigeria's capital on 12 December 1991, replacingLagos, though the latter remains the country's

most populous city. Its physiography is defined by the presence of two renowned rocks; Aso and Zuma rocks. Aso rock is a 400 metre monolith left by erosion. Zuma rock (Plate LXII: Zuma rock), also called "The gateway of Abuja" because the F.C.T begins at its base, a 792 metre monolith that lies just north of the city on the road to Kaduna state.

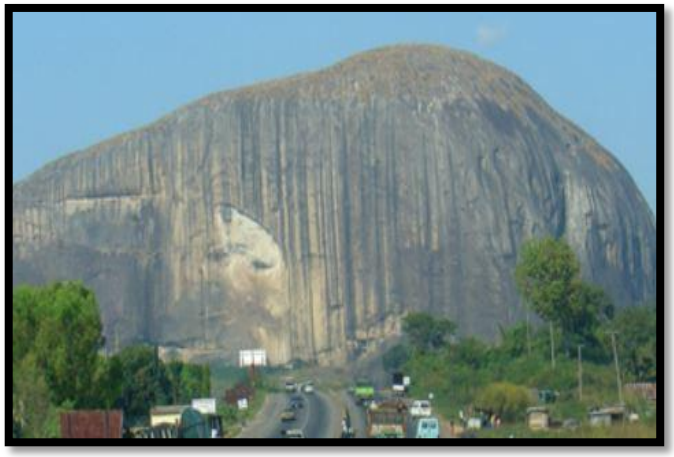


Plate LXII: Zuma rock
Source: Tourist link(2015).

5.2.1 Site Selection Criteria

According to Kito and Thomas (2011), these are criteria to be considered in choosing the most effective site for the development of a cancer hospital; Accessibility, land use compliance, biophilic significance, access to services, geographical zoning, ease for transportation of construction materials, site availability, distance from the city core, ease of future expansion and alternate energy source.

It should be noted that the process of selecting a site for the construction of a cancer hospital may not necessarily satisfy all the above criteria but helps to create a facility based on biophilic significance, resulting in a structure that will have positive impacts on human health and the environment at large.

5.2.2 Site Selection

Three alternate site were considered for the strategic location of the centre. These are:

Site A:

The site is located in Kukwaba district adjacent to National Hospital. It has a latitude of 9°03'34"N and longitude of 7°27'.48"E and it access through Yakubu Pam St. off constitution avenue (Figure 99).



Figure 9: Location of site 'A'
Source: Google Earth(2015).

Site B:

The site is located in Jabi district, bordering Kado area to its North in the F.C.T. It has a latitude of 9°04'50.35"N and longitude of 7°25'16.23"E.

The time zone is GMT+1 with an altitude of 450m above the sea level. It is located off Shehu Musa Yar'adua way (Figure 1010). The institutional facilities near the site include NISA hospital and Julius Berger water Front Park.



Figure 10: Location of site ‘B’
Source: Google Earth(2015).

Site C:

The site is located in research district and is accessible from Murtala Muhammad expressway. It has a latitude of 9°02'.94"N and longitude of 7°30'.60"E. Institutional facilities around the site is Infrastructure concession regularity commission (Figure 1111).



Figure 11: Location of site ‘C’
Source: Google Earth, (2015).

Table 5.1 shows the performance of each site against the selection criteria. The weighing factor ranges from 1-4 which represent the scale of – unacceptable, poor, fair, good and excellent.

Table 5.1: Sites' comparison

Criterion	Site A	Site B	Site C	Remarks
Accessibility	3	2	3	Site B and C are easily access directly from highways.
Land use compliance	3	2	3	Both site A and B are located within institution and research area of the F.C.T
Biophilic significance	1	4	1	Site B have biophilic significance as the result of its strategic location near Jabi lake
Access to services	4	3	2	Due to its location directly close to the highway, site A have more access to existing services line
Geographical zoning	1	3	1	Site B is located in a relatively quiet zone compared to the other sites
Ease for transporting of construction materials	4	2	4	Due to their location directly close to the highway, both site A and B have ease for transporting of construction materials
Site availability	4	4	4	All the sites are available
Distance from the city core	2	3	2	Site B is located much closer to the city core than the other sites.
Proximity to future expansion	1	3	1	Site B have more proximity to future expansion.
Alternate energy source	2	3	2	Site B have more provision of alternate energy source as the result of its strategic location near Jabi lake.
Total	24	**29**	23	

Weight Factor: 0–Unacceptable, 1-Poor, 2-Fair, 3-Good, and 4-execellent.

Source: Author, (2015)

Site B is selected as the proposed site for national comprehensive cancer centre based on its performance on the criteria discussed above.

5.3 Site 'B' Analysis

A general study of the site's micro-conditions is conducted in order to evaluate its potential treats and advantages. The following parameters are analysed: Visual, climatic and infrastructural analysis

5.3.1 Visual Analysis

To be familiar with site's visual surrounding, the following are considered: Neighbouring development, vista & attraction and soil type

5.3.1.1 Neighbouring development

The site surrounding is well developed with existing off-site facilities such as the existing Julius Berger water front park to the northern side and Kado residential development.

5.3.1.2 Vista and Attraction

The major vista and attraction of the site is the presence of Jabi Lake which is bordering the site to eastern side (Plate LXIII). The lake is at its highest tide during the rainy season. The lake's potential must be harnessed to play a central role in climate modification and other services on site. Its quantity should be improved to attain an all year round impact.



Plate LXIII: Jabi Lake
Source: Author's fieldwork(2015).

5.3.1.3 Soil Type

The soil on the site is deep and clayey, perhaps reflecting the influence of parentmaterials. However, thehigh sand content makes the soils to be highly erodible towards the existing Jabi Lake.

5.3.2 Climatic Analysis

The climatic study of the environment is critical to the design aspect of this research work so as to outline the influence of climatic elements that can affect the design within the locality of the site. Analysing the environment in relation to the climate of the site will unquestionably influenced the final design decisions.

The climate of Abuja features a tropical wet and dry climate with the following attributes: Topography, vegetation, precipitation, temperature, relative humidity, wind and sun radiation.

5.3.2.1 Topography

The site has an undulating surface with relatively flat pattern towards the access road and slopes eastward towards the existing Jabi Lake with a gentle terrain (Figure 12). The site drainage will take advantage of the slope direction to go with natural gravity. The project will take into consideration the topography of the site as a design tool during the planning stage.



Figure 12: Site's terrain
Source: Google Earth(2015).

5.3.2.2 Vegetation

The Site vegetation is characterized by a few grasses, shrubs and large trees. This is due to its location close to Jabi Lake. The vegetation is mostly evergreen towards the lake side (Plate LXIV). The site will be well landscaped and trees to be planted to reduce solar radiation and check soil erosion.



Plate LXIV: Site's vegetation.
Source: Author's fieldwork(2015).

5.3.2.3 *Precipitation*

The site experiences conventional and relief rainfall. The minimum monthly rainfall (in December) is 1mm, while the maximum rainfall in August is 138mm (Figure 13). The fall is more voluminous during this period than any other time and its cooling effect is better felt also. Gutters will be made on the roof to efficiently collect and discharge water from the roofs and site towards the lowest point on the site.

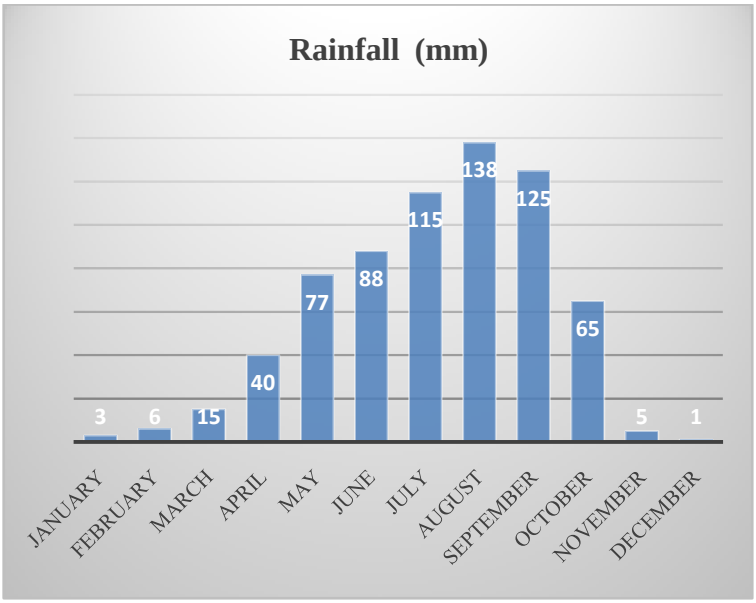


Figure 13: Monthly rainfall chart of Abuja.
Source: Gaisma(2015).

5.3.2.4 Temperature

The maximum mean monthly temperature of the site is 34.7 degree centigrade (Figure 14). February and March are usually the hottest months of the year. The extreme minimal temperatures are 28.2 and 18.7 degree centigrade in August and January respectively. In dry season, daytime temperature can soar up to 40 degree centigrade and in the night can be as low as 12 degree centigrade. The high altitudes and undulating terrain of Abuja moderate the influence of weather of the city.

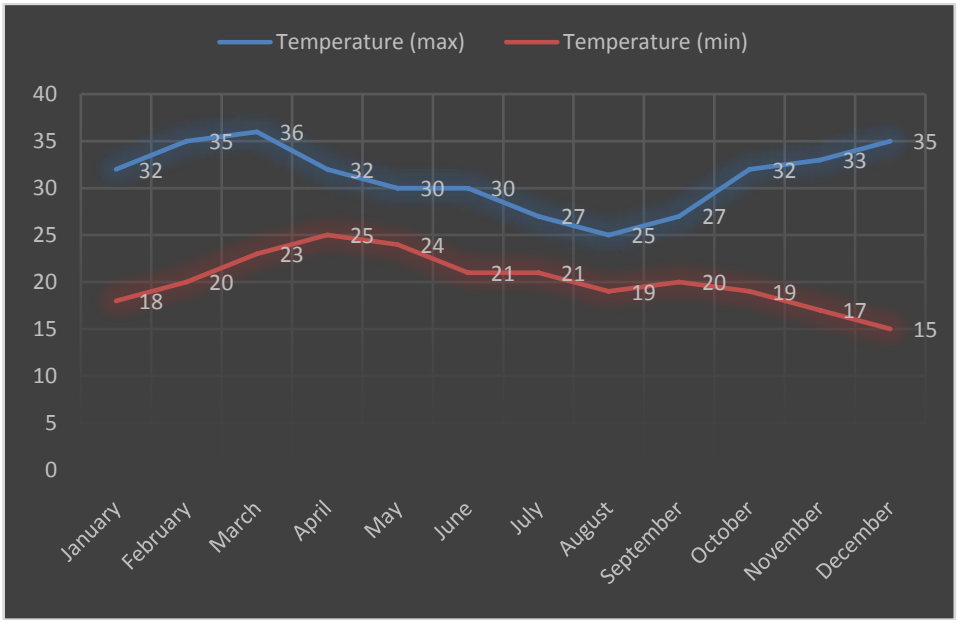


Figure 14: Monthly temperature chart of Abuja.
Source: Gaisma(2015).

5.3.2.5 Relative humidity

During rainy season, the relative humidity of the site is between 60 to 80% while in dry season is about 66% (Figure 15). It is usually high between January and April with an average of 55%. It however increases gradually to about 86% and decreases again between November and December to about 65%. The mean annual relative humidity is 75%. This result is affected by other factors such as sunshine, cloud cover and sun radiation.

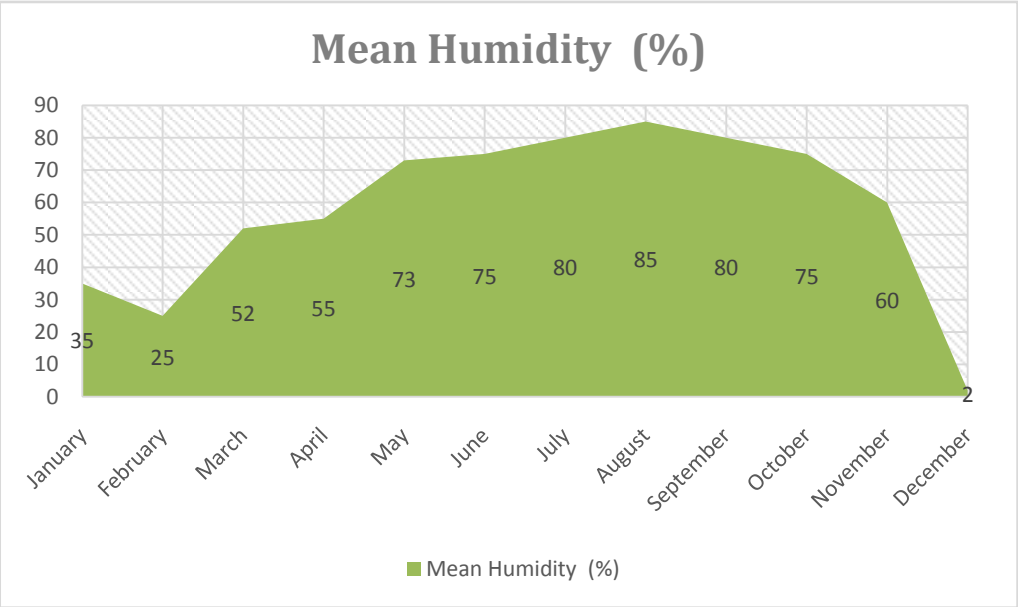


Figure 15: Frequency polygon of Relative humidity for Abuja.

Source: Gaisma(2015).

5.3.2.6 Wind

The two major air masses that reaches the site all year round are the tropical continental and tropical maritime air masses. The tropical a continental air mass enters through the NE part of the country from Sahara desert. It's associated with cool breeze accompanied with dust particles in dry season. The tropical maritime air mass blows from Indian Ocean and over Atlantic Ocean to the south-western part of the country, this air mass brings rain, thunderstorm and is often characterized by high humidity and cloud cover.

The average wind speed is about 7km/h with a standard deviation of about 23.9 and coefficient of variation of 17.9 (Figure 16). The exposure of the site to NE and SW trade winds can be used as energy source via wind mills. Their effect should be let into the facility in a controlled quantity for energy saving using natural means of ventilation.

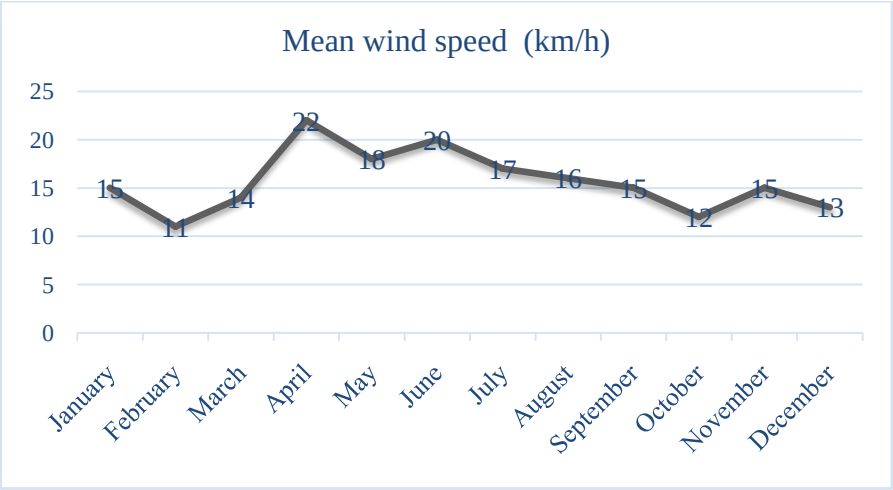


Figure 16: Frequency polygon of mean wind speed for Abuja.
Source: Gaisma(2015).

5.3.2.7 Sun radiation

Abuja being in the north-central part of Nigeria has its sun movement from the east through the north to the south. The sun rises from the east and gently warms up to its maximum heat intensity in the afternoon. As soon as the sun moves over to the west its intensity diminishes till it finally set (Figure 17).

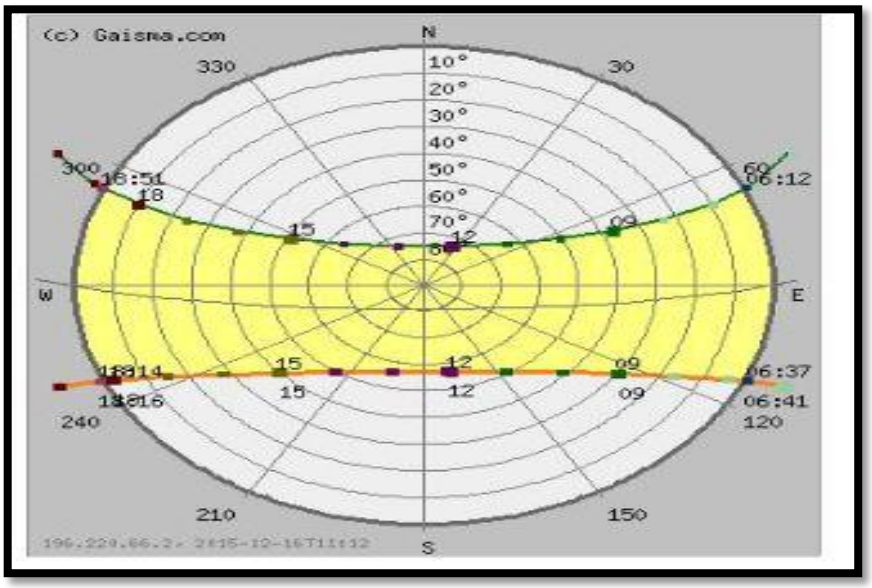


Figure 5.17: Sun path diagram
Source: Gaisma(2015).

Sun is available in sufficient quantity with greater effect in dry season and lesser effect in wet season due to almost constant cloud cover during the daytime. It is to be used as energy source via photovoltaic cells for light electrical equipment and its effect should be let in to the building for energy saving in natural lighting.

5.3.3 Infrastructural Analysis

To perform infrastructural analysis of the site, the following parameters were explored: Accessibility, source of noise, power supply, water supply and solid waste disposal.

5.3.3.1 Accessibility

The area within the site falls is completely defined and delimited by a system of main road networks, this however made the chosen site accessible by both pedestrian and pedestrian system. The site is access from the access road to its western side which originated from the Shehu Musa Yar'adua express way (Plate LXV)



Plate LXV: Shehu Musa Yar'adua way
Source: Author's fieldwork, (2015).

5.3.3.2 Source of noise

The major source of noise to the site is neighbouring Julius Berger water front park and motor able access road.

5.3.3.3 Power supply

There is existing 11kva power line along Shehu Musa Yar'adua highway (Plate LXVI) around the site and will serves as the potential power source to the facility. However, due to the inconsistent power supply experience, a power substation will be proposed for the facility.



Plate LXVI: Power cable along Shehu Yar'adua express way
Source: Author's fieldwork, (2015).

5.3.3.4 Water supply

There is existing supply of pipe-borne water to the site. This can be stored in tanks and reservoir which can later be pumped to the facility. More so, water treatment plant will be proposed to compliment the demand of the facility.

5.3.3.5 Solid waste disposal

No central system exist around the vicinity of the site, thus septic tank and central sewage treatment plant will be proposed for the facility.

5.4 Effects of Environmental and Climatic Factors on Building Design

Natural elements like climate, geology and vegetation can dictate the lifestyle of the occupants and landscape of the building. To create a good biophilic design, the following conditions will be considered:

5.4.1 Temperature

Design consideration under this are:

- Using of shading device mechanisms to reduce excess solar heat from reaching the interior spaces.
- Water will be used as a landscape element to help in reducing urban heat.
- Proper orientation of the facility to take advantage of the prevailing condition.
- Reducing the use of dark building finishes.

5.4.2 Humidity

-Being the site located near Jabi Lake, there will be high humidity in the area. There prompts the need for effective natural ventilation strategies.

-Proper damp-proofing will be made to reduce the rise of ground moisture.

5.4.3 Rainfall

-Proper roof structure to effectively discharge rain water.

-Adequate drainage to be provided within the site to prevent flooding.

-To check erosion, hard and soft landscape will be employ.

-Window hood, shading device and covered walkways will be proposed to prevent driving from reaching the interior spaces.

-Usage of water proof exterior finishes.

5.4.4 Wind pressure.

-The building component should be structurally stable to withstand the effect of wind pressure.

-Tress will be employed to serve as wind breakers.

-Proper orientation of the facility to allow the wind to reach its interior in a controlled quantity for natural ventilation.

5.4.5 Solar radiation

-Proper soft landscaping to reduce sun radiation at the outdoor environment.

-Use of shading device to reduce excess amount of radiation from reaching the interior spaces.

-Proper orientation of the facility to allow controlled quantity of lighting to reach the interior spaces.

6.0 CHAPTER SIX: DESIGN REPORT

6.1 Introduction

This chapter brings a synthesis of the knowledge gained through the review of related literature, the cases studied and site analysis conducted. Lesson learned from these formed an articulated design framework to accomplish an ultimate goal of creating biophilic cancer hospital.

6.2 Design Brief

As the greatest considerations in health-design have traditionally been functional, hygiene, efficiency, and flexibility for changing technology – hospitals have evolved to become dehumanizing spaces. In an effort to curtail the fast growing cancer cases in the country, the federal government of Nigeria Proposes the new cancer hospital that will serve as core of all related cancer activities in the country, both the research and clinical treatment of cancer. The propose design will provide state-of-the-art facility for proper administration of cancer cases and as well creates naturalistic and naturalistic environment which will connect the recovering patients with natural world to aid their physiological and psychological recovery.

The programs that will be provided in the facility include; Out-patient department, in-patient department, clinical complex, diagnostic areas, ancillaries and clinical support & functions. The detailed schedule of the design brief is presented in table 6.1.

Table 6.1: Schedule of design brief

Facilities	Department/Units
Out-patient department	• Registration • O.P.D • Emergency
Clinical complex	• Cancer clinics • Pharmacy • Surgical Unit • Chemotherapy
In-patient department	• Palliative ward • Paediatric ward • Male ward • Female ward
Diagnostic areas	• Radiotherapy • Radiology • Histopathology
Clinical support and function	• Oxygen plant • Central sterile department • Staff offices • Central administrative • Mortuary
Ancillary	• Restaurant • Laundry • Generator house

Source: Researcher(2016).

6.3 Design Concept Synthesis

Concept, architecturally, is a series of intentions or solutions originated in the mind to solve a particular architectural problem while considering other design factors. The two major concepts synthesised in the design of the hospital are site planning plan concept.

6.3.1 Site Planning Concept

The hospital layout was determined using the World Health Organization (W.H.O) emblem as inspiration (Figure 18). The main hospital complex was depicted as the world logo on W.H.O emblem while parking facilities arranged to mimic the way the flower is in the emblem.

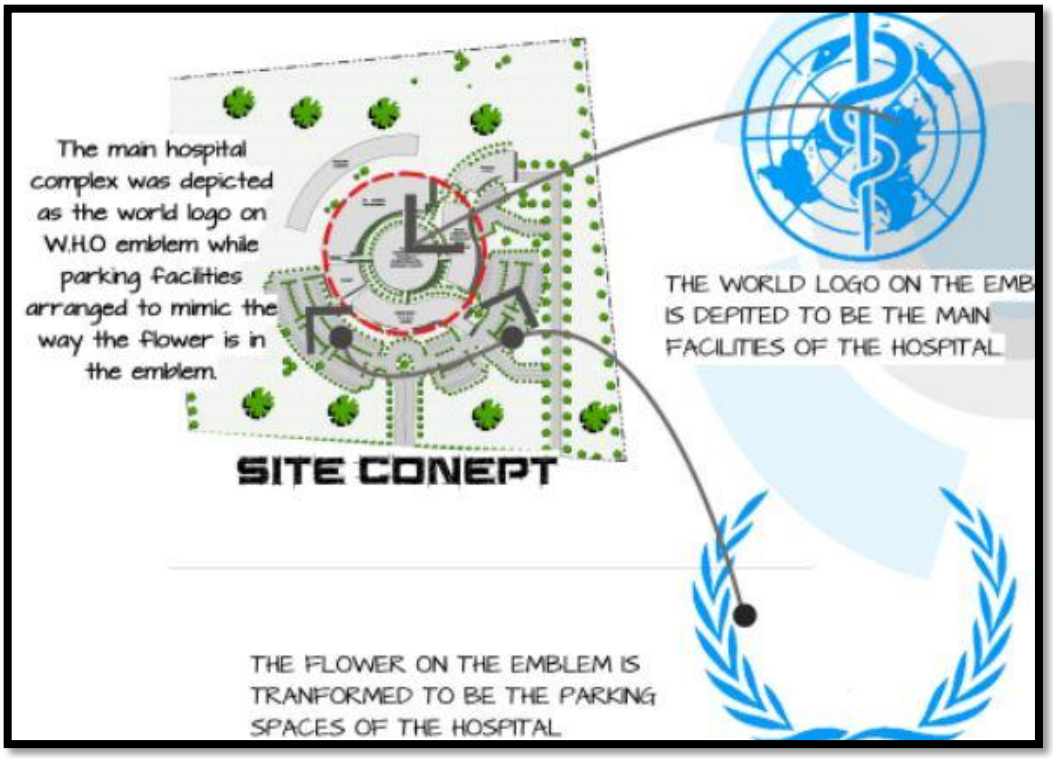


Figure 18: Site concept
Source: Author's sketch(2016).

The hospital is zoned into public & private areas, low traffic & high traffic, out-patient & inpatient, and therapies & diagnostic areas (Figure 19). The major and emergency entrances into the site were from the minor road on the western part of the site. This site planning concept helps in maximising balance in hospital flow and reducing noise level to confined public areas.

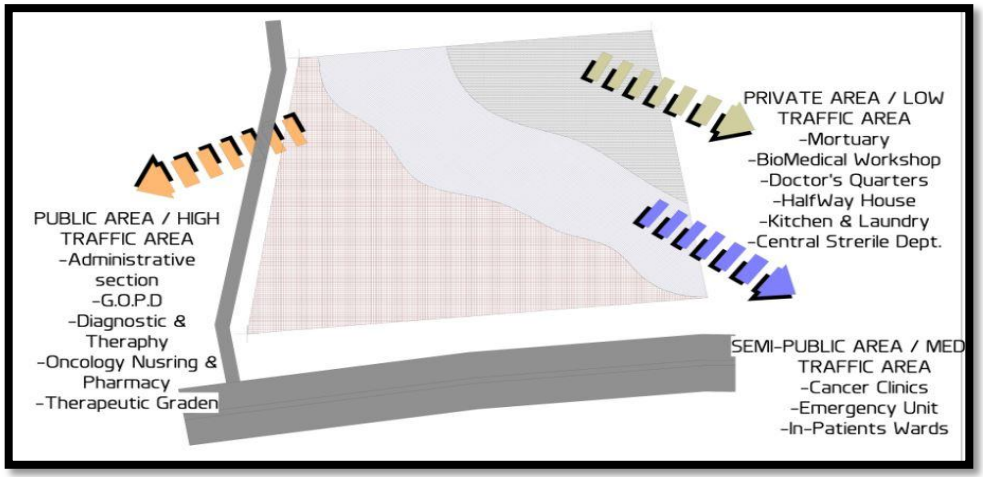


Figure 19: Site zoning concept
Source: Author's sketch(2016).

6.3.2 Plan Concept

The plan concept was synthesized from one of the major patterns of biophilic design; water droplet. Water is considered by many as source of life and inspiration.

The plan concept is formed by mimicking a droplet of water and the waves that radiates from it when it touches a water surface (Figure 20). The water droplet is major clinical complex, while the waves that are radiating away formed the remaining clinical departments, support and functions.

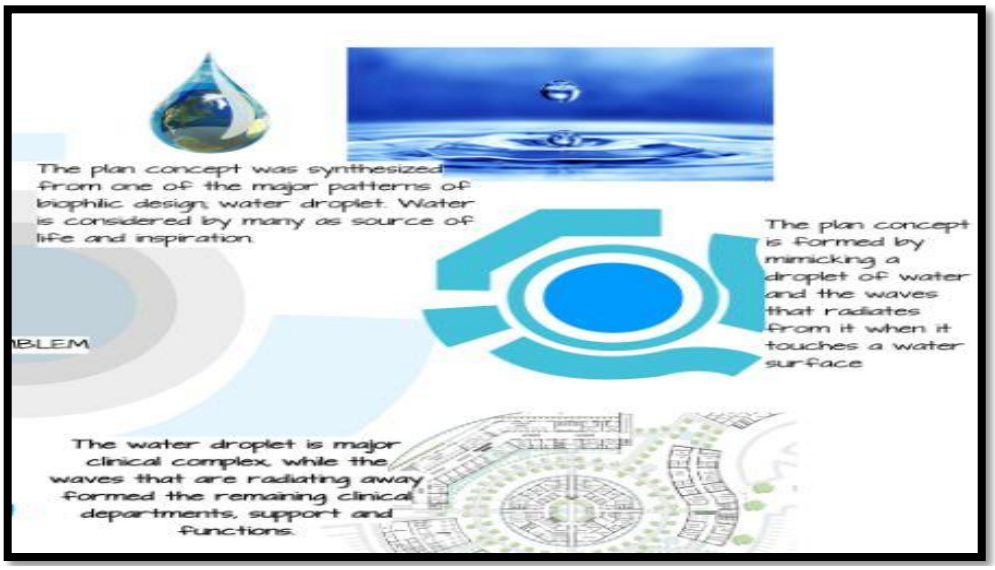


Figure 20: Site zoning concept
Source: Author's sketch(2016).

6.4 Biophilic Design Patterns Applied

In order to create naturalistic environment in the design of the national cancer hospital, attributes of biophilic design patterns has been applied to various degrees. The application of these attributes of this biophilic design patterns have been found to have not only the restorative and calming effect, but also helps in reducing stress by providing opportunities of escape from clinical settings.

Thirteen patterns of biophilic design under three broad categories are incorporated in the design of the hospital. The first category 'Nature in the space' have seven patterns; Visual connection with nature, non-visual connection with nature, non-rhythmic sensory stimuli, presence of water, dynamic & diffuse light, thermal airflow & variability and connection with natural systems. The second category 'Natural analogues patterns' have three patterns; biomorphic forms & patterns, material connection with nature and complexity & order. The last category is 'Natural of the space' and have three patterns too; prospect, refuge and mystery.

6.4.1 Visual connection with nature

- Adequate provision of varied landscaping and vegetation are made in the design of the hospital (Plate LXVII).



Plate LXVII: Varied landscaping & vegetation
Source: Author's sketch(2016).

The factors taken into consideration for selecting flora to be used in the hospital include: Suitability of climate, healing attributes of the plants, maturity size, and resistance to pest, clinic suitability, and soil PH requirement.

- Healing garden, or therapeutic garden, are landscape settings that promote health and wellbeing. This garden is design to have both physical and psychological benefits to the cancer patients by providing sense of fascination to a greater extent, separating them from distraction, reducing negative emotions, holding their attention and blocking stressful thoughts. The garden is easily accessible from the main in-patients' department. The elementary modules of a typical healing garden include flora, fauna, water bodies, constructed soft and hard landscape elements (Plate LXVIII). Most attention was given to the flora and use of water to stimulate the healing process not only in the healing garden but in also different public spaces of the hospital like waiting areas, landscaped areas, roof gardens, balcony planting, courtyards and major entrances.



Plate LXVIII: Ariel view of the healing garden
Source: Author's sketch (2016).

6.4.2 Non- visual connection with nature

Thehospital complex is planned so that the parking facilities are arranged to minimize noise level within the clinical core of the complex (Figure 21). Trees and low maintenance gardens are provided to create a buffer zone which prevents sound from travelling to the quite zones of the hospital.

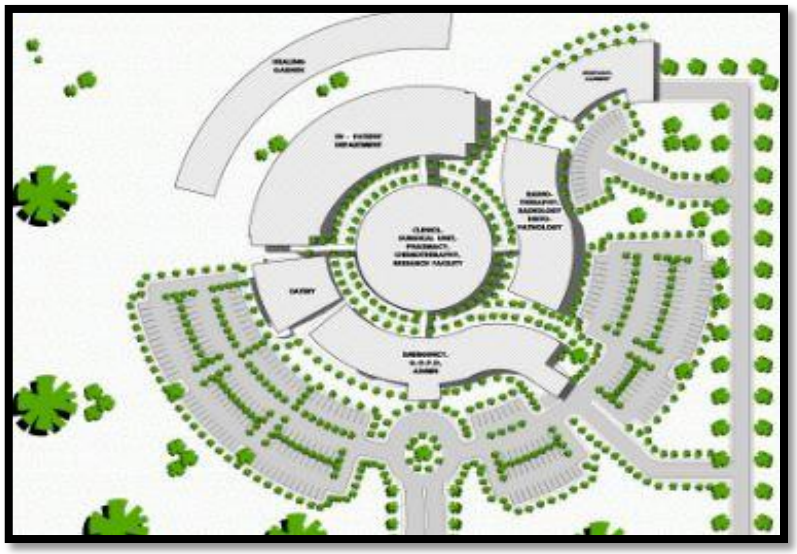


Figure 21: Proper segregation of parking facilities
Source: Author's sketch, (2016)

6.4.3 Non-Rhythmic sensory stimuli

- The use of colour in interior spaces of hospital has a therapeutic effect. For this reason, careful selection of paint colour of white and green has been applied in the interior spaces of the in-patient department to make it less intimidating. Much emphasis was made in the paediatric ward to cater for children's preference of colour in healthcare settings.
- There is adequate provision of indoor &balcony planting (Figure 22). These planting are specifically placed in the patients' wards so that the patients can be exposed to natural world without necessary going out of the main facility. The flora provided here are carefully picked to enhance aesthetic, sensory and general indoor

qualities. The balcony plants also has additional functional benefits like reduction of cooling load and ambient temperature, and enhancement of indoor air quality.



Figure 22: Use of balcony planting in the in-patient department
Source: Author's sketch(2016).

An interior space with improve air quality feels refreshing and invigorating. This type of environment have restorative and calming effect to the patients. Some of the plants includes slender palm lily, cascade palm, lipstick vine and Boston ferm.

6.4.4 Thermal airflow and variability

- Proper orientation of the hospital coupled with differing position of windows provides subtle air changes in the indoor spaces of the hospital (Plate LXIX).



Plate LXIX: Adequate provision of windows
Source: Author's sketch (2016).

- The in-patient department is designed using double banking. However, openings are provided in the main corridor of the subsequent floors to allow exhaust air to escape through the openings provided at the roofing's skylight(Plate LXX).



Plate LXX: Skylight over in-patients' ward
Source: Author's sketch(2016).

6.4.5 Presence of water

Water features like fountain (Plate LXXI.) and cooling ponds are carefully integrated in to the design of the hospital around the in-patient department and clinical core to capitalize on the multi-sensory attributes of water and enhance the patients' hospital stay in a manner that is soothing, prompts contemplation, enhances mood and provides restoration from cognitive fatigue.



Plate LXXI: A water fountain.
Source: Author's sketch(2016).

6.4.6 Dynamic and Diffuse light

There is adequate placement of windows to capture dynamic and diffuse light within the interior of the building. Solar shading devices were provided to reduce excess amount of light from reaching the interior spaces (Plate LXXII).



Plate LXXII: Solar shading device
Source: Author's sketch (2016).

6.4.7 Connection with natural system

- The in-patient department is spatially located in the site so the patient can have unrestricted view to the existing Jabi Lake at the eastern end of the site (Plate LXXIII).



Plate LXXIII: Locating the in-patient deppartment to have visual access with Jabi lake
Source: Author's sketch(2016).

6.4.8 Biomorphic forms & Patterns

- The interior walls of the in-patient department is finished with wooden finishes with botanical motifs engraving.
- The façade of the main clinic complex and the in-patient department is biomorphic in nature while enhancing the dynamic & diffuse light and shadows filtering in to interior spaces (Plate LXXIV). This provides facades that captivates view of the patients to reduce their cognitive stress. Also the interior finish of the patients' rooms is decorated using graphic plant-like images on the wooden finishes.



Plate LXXIV: Biomorphic (honey comb) façade of the in-patient department
Source: Author's sketch(2016).

6.4.9 Material connection with nature

Sustainable building materials are used as both building material and finishes. Compressed earth brick were used as the main walling materials while wooden finishes are applied in the interior spaces of in-patient and out-patient departments.

6.4.10 Complexity & Order

The main form of the facility mimics a water droplet with a complex series of solar shading devices that complements each other in a repetitive order (Plate LXXV).



Plate LXXV: Complex shading device that mimics the shape of water droplet
Source: Author's sketch(2016).

6.4.11 Prospect

The hospital is spatially planned so the main buildings and the fenestration network optimizes visual access to the outdoor vistas. More so, the fenestration networks linking the facilities together are designed using a green wall system (Plate LXXVI).



Plate LXXVI: Green wall system on walkways
Source: Author's sketch(2016).

Green walls are vegetation that are suspended on a wall system. This helps in bringing the outside natural world into the built environment and as the result connect the recovering patients with nature. The advantages of the green wall include; Reduction of solar radiation gained, creating wind barrier, and enhancing transpiration which reduces extra cooling load.

6.4.12 Refuge

Use of biomorphic shading devices and differing orientation of windows throughout the hospital complex creates change in light levels within interior spaces, thus creating a sense of refuge to the patients and caregivers.

6.4.13 Mystery

Green roof is provided on the in-patients' ward and the adjacent clinical core of the hospital (Plate LXXVII). This ensures easy accessibility by the patients and as well expose them to the natural world for their psychological and spiritual needs. The basic component of the green roof includes vegetation laid over a growing medium, on drainage and root barrier, on insulation layer, on membrane protection layer, on roofing membrane, on structural support (roofing concrete deck).



Plate LXXVII: Semi-intensive roof garden
Source: Author's sketch(2016).

6.5 Architectural Design of the Cancer Hospital

The cancer hospital was designed into basically four components structures radiating from the main clinical core. The separation of these structures reduce the stress associated with way finding in hospital design, enabled proper organization for effective management and provides environment with adequate spaces for natural landscape elements which is more soothing to the patient and their relatives. Separating these functions also makes it easier to run various components of the hospital without interference with each other. This ultimately translates into healthier healing and recovery of the patients.

The basic components of the hospital includes;

6.5.1 General Out-patient Department

This department is the first point of contact to either first-time or referred patient. It provided avenue for registration, consultation, investigation and initial diagnosis of cancer. From here, patients are sent further for diagnosis in histopathology and radiology department. Form the initial diagnosis, patients are distributed to different cancer clinics depending on the nature and the growth of their malignancies (Figure 23).



Figure 23: A sketch of G.O.P.D
Source: Author's sketch(2016).

6.5.2 Emergency Unit

This department his responsible the emergency cases of the first-time and referred patients. The department has easy accessibility to the chemotherapy and radiotherapy department. Its intensive care unit/recovery caters for the patients that are prescribed for chemotherapy or making their recovery for surgical procedures (Figure 24).

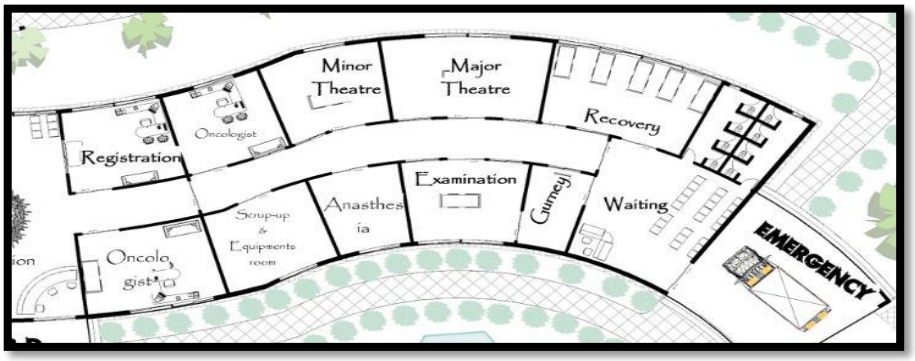


Figure 24: A sketch of emergency department
Source: Author's sketch(2016).

6.5.3 Clinics

Patients are distributed to the appropriate clinics where they will undergo thorough consultation by specialist oncologist. Patients that require intensive care are admitted into the in-patient department and are prescribed for either surgery, chemotherapy, or cancer and pain drugs medication. There are about 8 different clinics and each has two consulting rooms, medical records and waiting areas (Figure 25).

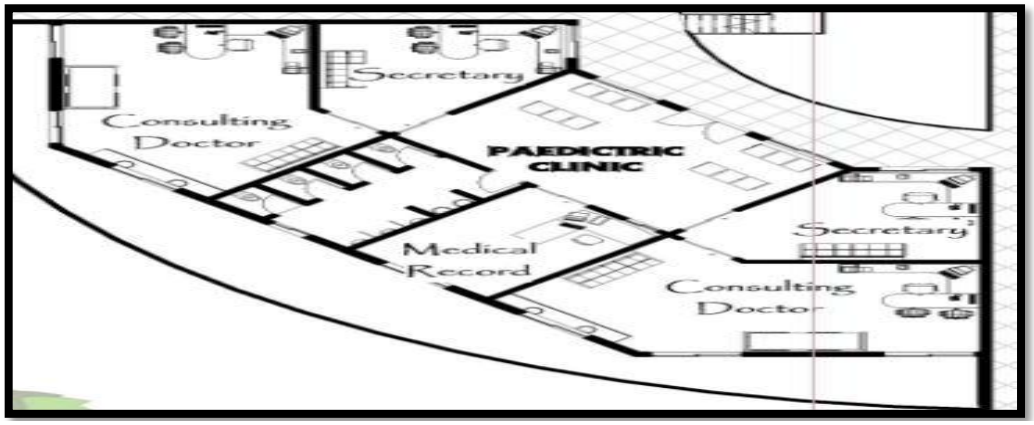


Figure 25: Spatial organization of a typical clinic
Source: Author's sketch(2016).

6.5.4 In-patients wards

This department provides housing to the patients for their period of recovery. The research design caters for female, male, paediatric and palliative wards. It also provides for each department a general ward, single bed room, double bedroom, rest rooms, internal garden, communal patients' dining area, healing balcony and conveniences (see Figure 26). Special emphasis were made on palliative ward to provide a sanatorium spaces within the hospital for the patient with terminally ill cancer. The department make provision of indoor therapeutic landscape and psycho-oncology to reduce patients' depression. It is also located on the ground floor to have easy visual and physical accessibility to the healing garden.



Figure 26: Spatial organization of a typical in-patient ward.
Source: Author's sketch(2016).

6.5.5 Pharmacy

The department was located in the central core of the hospital so it can distribute easily medication and materials required in the treatment areas. The department provides drugs cancer treatment, management and pain medication. It has a small waiting area, drugs & pain medication store and compounding lab for drug investigation (Figure 27).

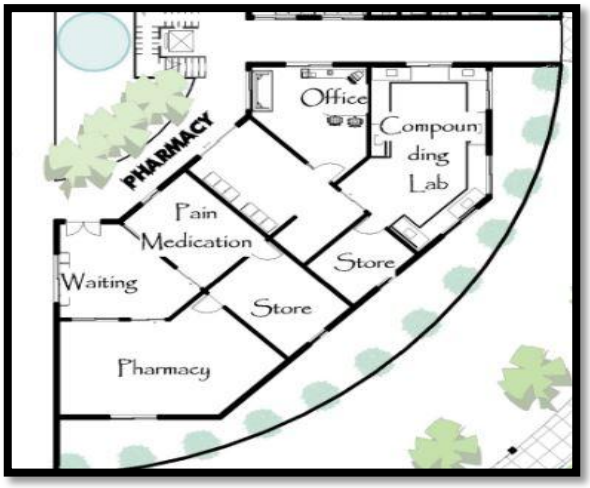


Figure 27: Spatial organization of a Pharamacy department.
Source: Author's sketch(2016).

6.5.6 Surgical department

This department provides avenue to perform complex procedure to the cancer patients. The research design provides this department with two major and minor surgical rooms, waiting areas, recovery, and intensive care units (Figure 28).

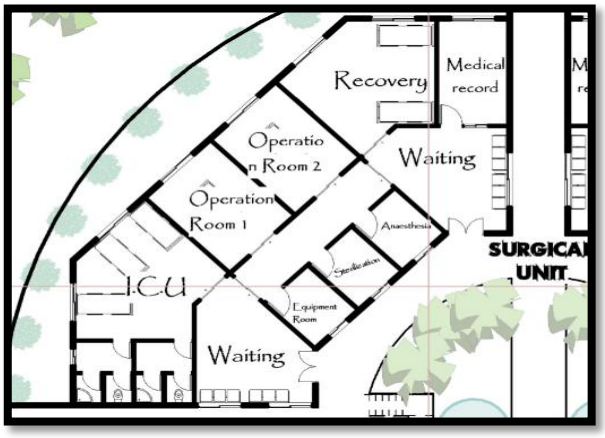


Figure 28: Spatial organization of a surgical department.
Source: Author's sketch(2016).

6.5.7 Radiology department

This department handles internal imaging of patients on either cathode ray tubes or film. The facilities provided includes Magnetic resonance imaging (MRI) scanning, Convectional X-ray, Positron electron tomography (PET), and Computed tomography (CT) scanning (Figure 29).

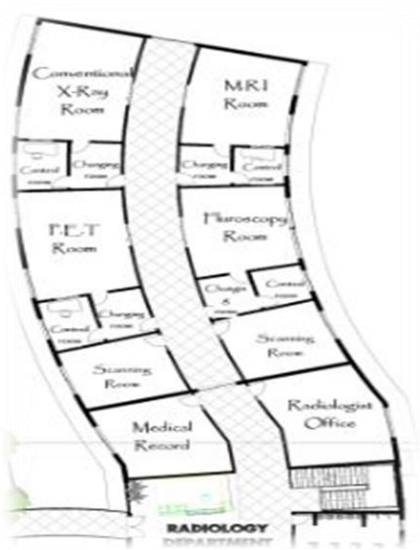


Figure 29: Spatial organization of radiology department.
Source: Author's sketch(2016).

6.5.8 Radiotherapy department

This department offers nuclear medicine service. Radiation sourced either by man-made or natural means are used to reduce or eliminate cancerous cells and tumours. The services offered includes immunotherapy, hormonal therapy and brachytherapy (Figure 30).



Figure 30: Spatial organization of radiotherapy department.
Source: Author's sketch(2016).

6.5.9 Histopathology unit

This cater for all the laboratory diagnostic activities. The test carried out in this department reveals the nature, cause and extent of the malignancies. Some of the test carried out include pathology, serology, haematology, immunology and histology (Figure 31).

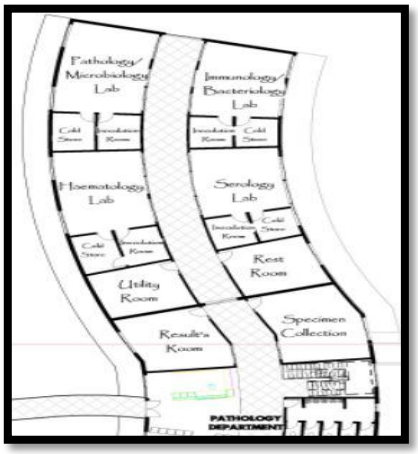


Figure 31: Spatial organization of histopathology department.
Source: Author's sketch(2016).

6.5.10 Central sterile and supply department (CSSD)

This department sterilizes and clean equipment for re-use in the treatment areas. It is done either thorough chemical or heating means. The department has waiting area, refrigeration section, steaming section, sterilization lab and clean equipment store (Figure 32).

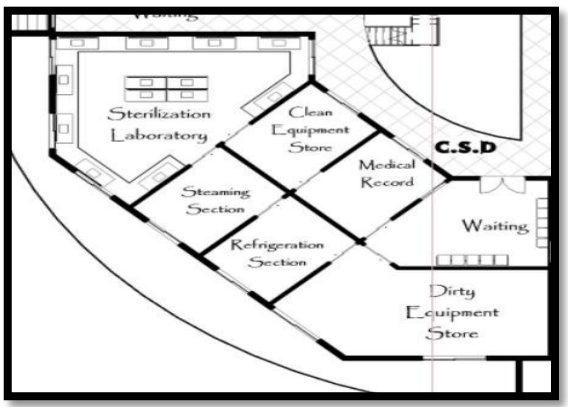


Figure 32: Spatial organization of C.S.D department.
Source: Author's sketch(2016).

6.5.11 Cafeteria

This unit provides fast and solid food to the hospital community. It also prepares special diet to patients to booster their recovery rate. It has kitchen, cold & dry store, eating hall and workers' cloak room (Figure 33).

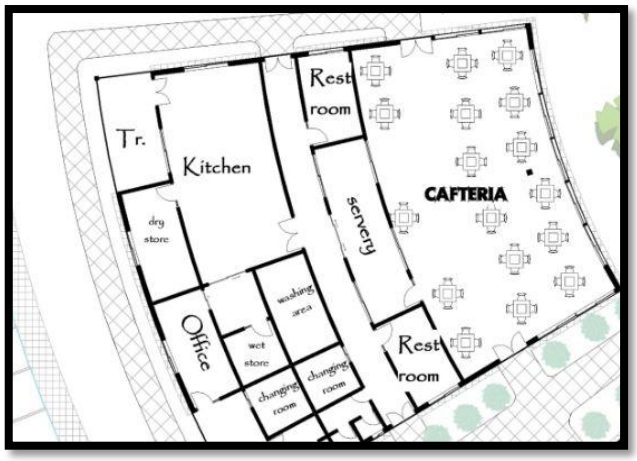


Figure 33: Spatial organization of cafeteria.
Source: Author's sketch(2016).

6.5.12 Mortuary

The mortuary is located away from the main clinical core of the hospital but have easy accessibility from in-patient department and outside of the hospital. It has about 40 storage cubicles with separate loading and offloading bay (Figure 34).

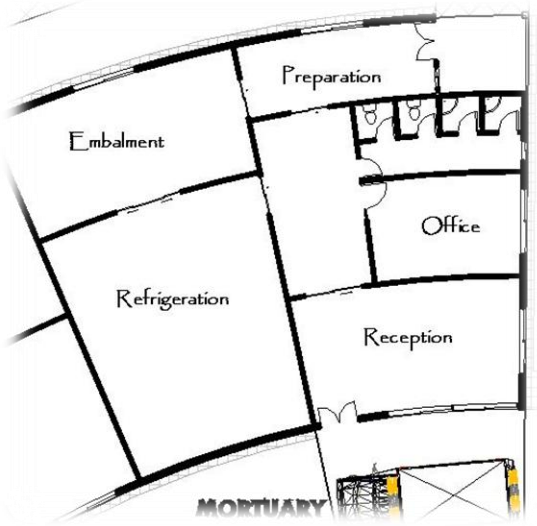


Figure 34: Spatial organization of mortuary
Source: Author's sketch(2016).

6.6 Method of Construction

The construction of the hospital was done in stages that includes foundation system, frame structure, walling, flooring roofing and finishes.

6.6.1 Frame Structure

The construction of the hospital was done using framing method. This employs the use of skeletal grid system comprising of beams and columns arrangement.

6.6.2 Walling System

The exterior walls are predominantly made up of compressed earth bricks of 225x225x350mm because of their high thermal mass. Expansion joints are provided at intervals (Figure 35). Interior partitions walls of 150x225x450mm were employed in the clinical core of the hospital. Concrete, steel and lead of calculated thickness were used in the radiotherapy department for shielding of x-rays.

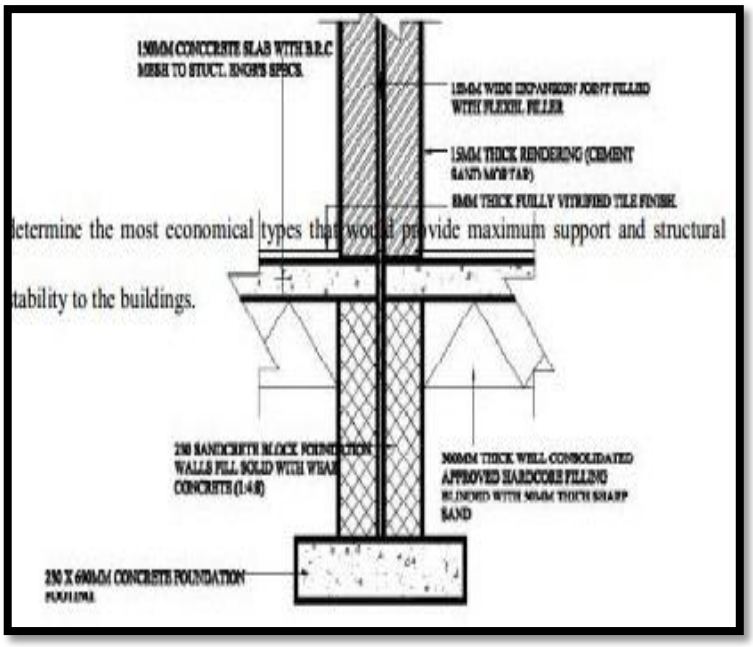


Figure 35: A detail of expansion joint
Source: Author's sketch(2016).

6.6.3 Roof

The roof construction is divided in to two parts; conventional roofs and semi-intensive roof gardens. The conventional roofs are made up of steel truss system and long span aluminium sheet while the semi-intensive roof garden consist of vegetated roofing materials laid over a concrete slab.

6.6.4 Floors

The flooring system of the hospital is made of concrete, steel and bricks. The ground floor is well reinforced concrete slab laid on water-proofing material while the subsequent floors consist of 75mm concrete with reinforced bars on hollow clay pot (Figure 36).

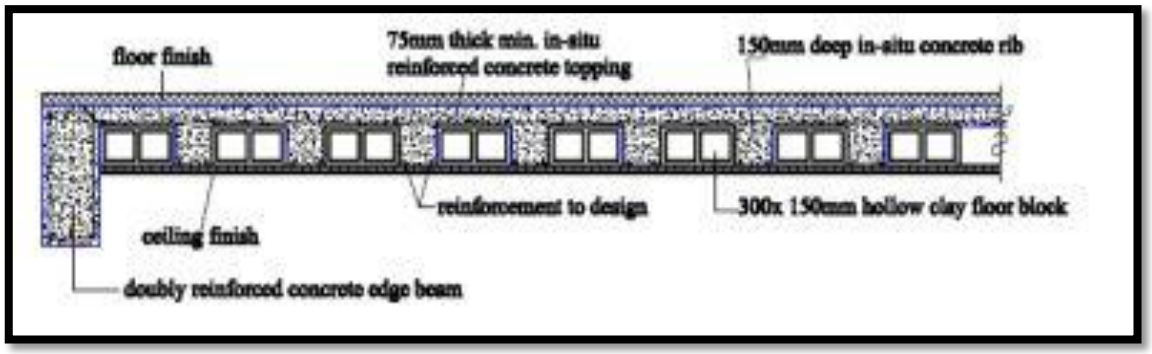


Figure 36: A detail of hollow pot floor
Source: Author's sketch(2016).

6.7 Services

In an effort to provide comfortable healing and naturalistic environment in the hospital, the following provision of services were made:

6.7.1 Power Supply

Power will be tapped from the existing power distribution network of Abuja Energy Distribution Company (AEDC) around the vicinity of the hospital.

However, the design shall cater for its power needs. Solar panels will be installed to provide clean energy and reduce over-dependence on the AEDC's grid, and also cater for power failure.

6.7.2 Water Supply

The hospital will be equipped with water supply from the existing water supply line in the area of the hospital. Water generation and recycling plant will be proposed so the hospital can satisfy its own water needs

6.7.3 Refuse Disposal

Small incinerator will be proposed at the remote part of the site for the incineration of non-toxic waste. Waste coming from varying types of radioactive materials in the radiotherapy department should be kept in their original lead-shielded containers and monitored with radiological survey instrument before carefully taken away from the hospital.

6.7.4 Storm Water Drainage

Storm water should be drain form the clinical areas using concrete gutters that follows the site's terrain and discharged into the existing Jabi Lake at the northern end of the site.

6.7.5 Sewage Disposal

Non-toxic waste water should be drain through central sewer system to sewage treatment plant and later disposed by Abuja Environmental Protection Agency.

7.0 CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

7.1 Summary

The healthcare industry originally focuses on clinical needs despite strong evidence proving that there is one factor that plays a larger role in health outcomes improvement. This research work was built on the subject of integrating biophilic design patterns in the design of national cancer hospital, with the problem being that the previous approach of the existing hospitals devoid of necessary considerations in providing naturalistic spaces that will help in connecting the recovering patients with natural world. Thus, biophilic design offers a better approach towards the provision of restoring and calming environment required to ease the psychological stress of cancer patients. This argument draws its background from the study of relevant literature.

Review of relevant literature in biophilia and its implication of mental health aided in capping a set of design rules on how to integrate biophilic architectural strategies that has direct medical and psychological impacts on cancer patients into the built environment. Cases studies were analysed in order to find out how (if at all they exist) these architectural strategies were adopted in the existing cancer hospitals, and how they will subsequently be adapted in the design of new biophilic cancer hospital.

The concept of the hospital stems from one of strong pattern of biophilic design discussed in literature review. The complex consists of main clinically core in form of water droplet and the remaining facilities are radiating from it like waves of water.

The design was conceived through an understanding of biophilia that will evolve architecture natural enough to offer positive distraction to its users.

This thesis provides contextual information on cancer, its resulting mental effect and explore the architectural strategies of biophilic design patterns which will assist in creating supportive and naturalistic environment to supplement the patients' needs. Effort was made to incorporate the biophilic strategies that has direct medical and psychological benefits to the cancer patients in the design of the hospital.

The main goal of this research was to create a healing environment in cancer hospital unlike any other existing today. Thus, the research provides a basic design guidelines of creating a healing built environment in health care architecture, specifically.

7.2 Conclusion

Biophilic design is intricate, but satisfying area of sustainable architecture. To be able provide comfort and healing to patients with psychological and cognitive stress is a unique opportunity. Over the course of this research, the notion that nature's healing and restorative impact are insightful was repeated over and over again. Instead of designing without nature, this research thesis have proved that there is numerous beneficial impacts on the patients by designing healthcare settings with nature in mind. Providing naturalistic spaces within health care settings allows the patients the opportunity to harness the healing properties of nature and surrounds themselves with one of the most basic needs, connection to life.

7.3 Recommendation

In view of the anticipated benefits of designing with nature in healthcare settings, architects and designers are urged to make conscious decision in bringing nature into the built environment. This is immensely important because many environmental and nature-based design solutions has been found to affect healthcare outcomes, such as the reduction of excessive noise; access to daylight, especially sunshine; and usage of

sustainable natural building materials. It has also been noted that environmental stimuli of an emotional or cognitive nature may act through psychological processes as a result of sensory perceptions, whereby the presence of plants in healthcare setting, for instance, reminds patients of home, thereby decreasing anxiety and promoting recovery. Moreover, bringing nature to help in stress reduction is important not only for the patients but also the staff as undue stress generates negative effects on caregivers just as it does on patients.

7.4 Contribution to Knowledge

This thesis focuses on integrating nature into the design of cancer hospital thereby creating a connection between life, nature and the built environment which evolve architecture that can positively contribute to the healing and psychological recovery of the patients. From the outcome of the research and design process in this thesis, it can be inferred that;

i. The research was able to develop a framework (encompassing patterns & strategies) for a healthcare architecture using patternsbiophilic design that have positive effects on stress reduction, depression, and facilitate positive experience in a hospital.
ii. From the analysis of the cases studied under three broad categories of biophilic design, ‘Nature in the Space Patterns’ were reflected the most with average score of 3.1 out of 4, while ‘Nature of the Space Patterns’ and ‘Natural Analogues Patterns’ have the scores 2.6 and 2.1 respectively. The result demonstrated that ‘Nature in the Space Patterns’ are more favoured in the design of health care settings which provides spaces that promotes healing and ease psychological stress of patients.

iii. The research supports measureable, positive impacts of biophilic design on health, buttressing the pragmatic evidence of human nature connection and increases its importance level within both design research and design practice.

7.5 Area of further research

After careful deliberation on the findings of this research thesis, some grey areas were highlighted where additional research could be supportive in the same area of bringing nature in to cancer hospital. These includes the following;

I. Further research can be done in how to incorporate the fourteenth pattern of biophilic design, risk/peril, into a cancer hospital, as it is not included in this research because of scope limitation.

II. Use of only one pattern of biophilic design, for instance, visual connection with nature, to see how interior landscape can be a life enhancing tool in the pain management of cancer patients.

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APPENDIX LIST

Appendix I: Developing biophilic design conceptual framework

PATTERNS OF BIOPHILIC DESING (Terrapin, 2014)	BIOPHILIC STRATEGIES	**Wilson (1984)**	**Ulrich (2008)**	**Heerwagen (2006)**	**Kahn (1991)**	**Kellert (2008)**	**Hilderbrand (2000)**
1. Visual connection with nature.	- Provision of varied landscaping and vegetation -Unrestricted views of nature and vistas from the interior -Provision of healing gardens	✓			✓	✓	
2. Non-visual connection with nature.	-Access to nature sound over urban sounds -Integration of natural ventilation and presence of water		✓	✓	✓		
3. Non-rhythmic sensory stimuli.	-Use of warm colours for sensory stimulations -Provision of indoor landscape.	✓		✓			✓
4. Presence of water.	-Use of water as a landscape element (Fountain & aquarium).	✓		✓	✓	✓	✓
5. Dynamic & diffuse light	-Placement of windows to capture dynamic and diffuse light within the interior of the building -Use of reflective surface to enhance lighting and mitigates glare		✓	✓			✓
6. Thermal airflow &variability.	-Design with respect to sun and wind orientation -Placement of windows to allow natural ventilation	✓	✓		✓		

7. Connection with natural system.	-Provision of visual to existing natural system within the site.				✓		✓
8. Biomorphic forms & patterns.	-Use of botanical interior motifs -Applications of organic shapes in building exterior		✓		✓	✓	
9. Material connection with nature.	-Use of sustainable building materials -Use of natural colour pallet like green within the interior spaces	✓		✓			✓
10.Complexity & order	-Complex architectural expression and landscape planning -Integration of buildings parts into whole		✓	✓	✓		✓
11. Prospect	-Orienting building, fenestration or corridor to optimise visual access to outdoor vistas -Designing around existing or planned savannah-like ecosystem		✓		✓	✓	
12. Refuge	-Change in light levels within the interior	✓		✓		✓	
13. Mystery	-Provision of low maintenance garden. -Preference of curve edges than sharp corners within the interior spaces	✓	✓		✓	✓	✓

Source: Researcher, 2015

Appendix II: Case study checklist sample

PATTERNS OF BIOPHILIC DESIGN	ATTRIBUTES	LEVEL OF REFLECTION				REMARK
		Abs	Low	Med	High	
Visual Connection With Nature	- Provision of varied landscaping and vegetation -Unrestricted views of nature and vistas from the interior -Provision of healing gardens					
Non-Visual Connection With Nature	-Access to nature sound over urban sounds -Integration of natural ventilation and presence of water					
Non-Rhythmic Sensory Stimuli	-Use of warm colours for sensory stimulations -Provision of indoor landscape.					
Thermal Airflow & Variability	-Design with respect to sun and wind orientation -Placement of windows to allow natural ventilation					
Presence Of Water	-Use of water as a landscape element (Fountain & aquarium).					
Dynamic & Diffuse Light	-Placement of windows to capture dynamic and diffuse light within the interior of the building -Use of reflective surface to enhance lighting and mitigates glare					
Connection With Natural System	-Provision of visual to existing natural system within the site					
Biomorphic Forms & Patterns	-Use of botanical interior motifs -Applications of organic shapes in building exterior					
Material Connection With Nature	-Use of sustainable building materials -Use of natural colour pallet like green within the interior spaces					
Complexity & Order	-Complex architectural expression and landscape planning -Integration of buildings parts into whole					
Prospect	-Orienting building, fenestration or corridor to optimize visual access to outdoor vistas -Designing around existing or planned savannah-like ecosystem					
Refuge	-Change in light levels within the interior					

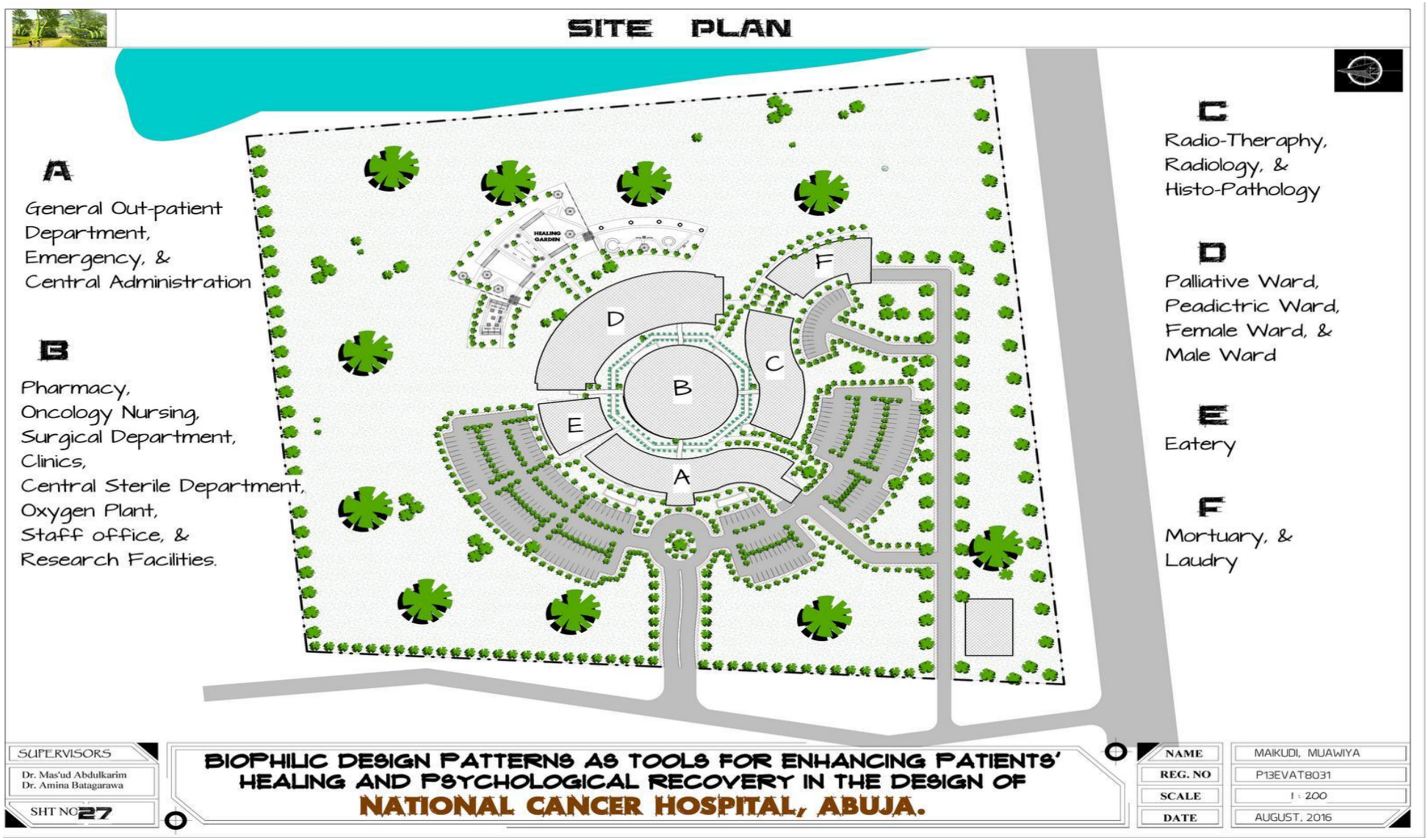
Appendix III: Pyschological depression among cancer patients

Appendix IV: Hobby distribution among cancer patients

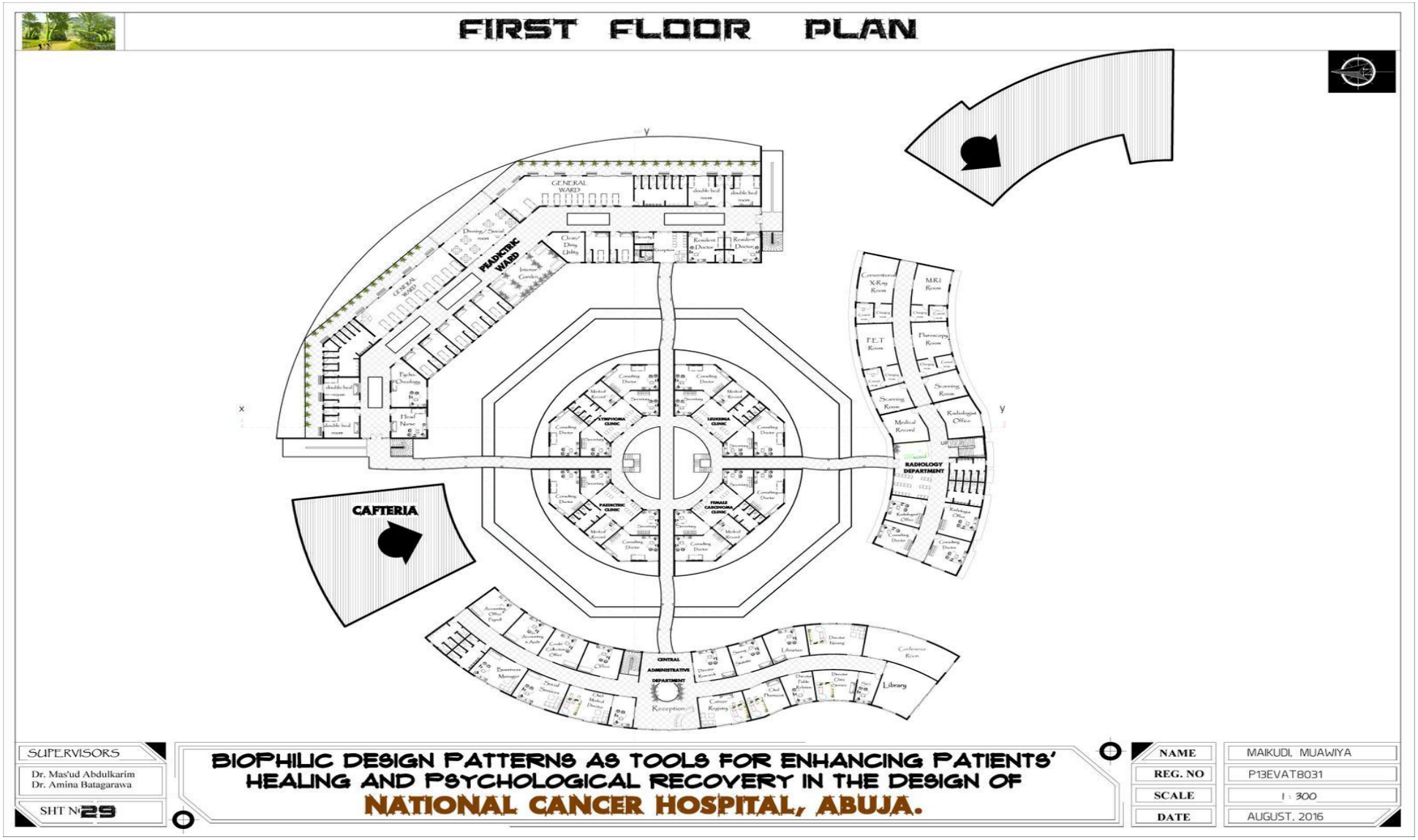
Source: Researcher's fieldwork, (2016).

Appendix V: Causes of psychological depression among cancer patients

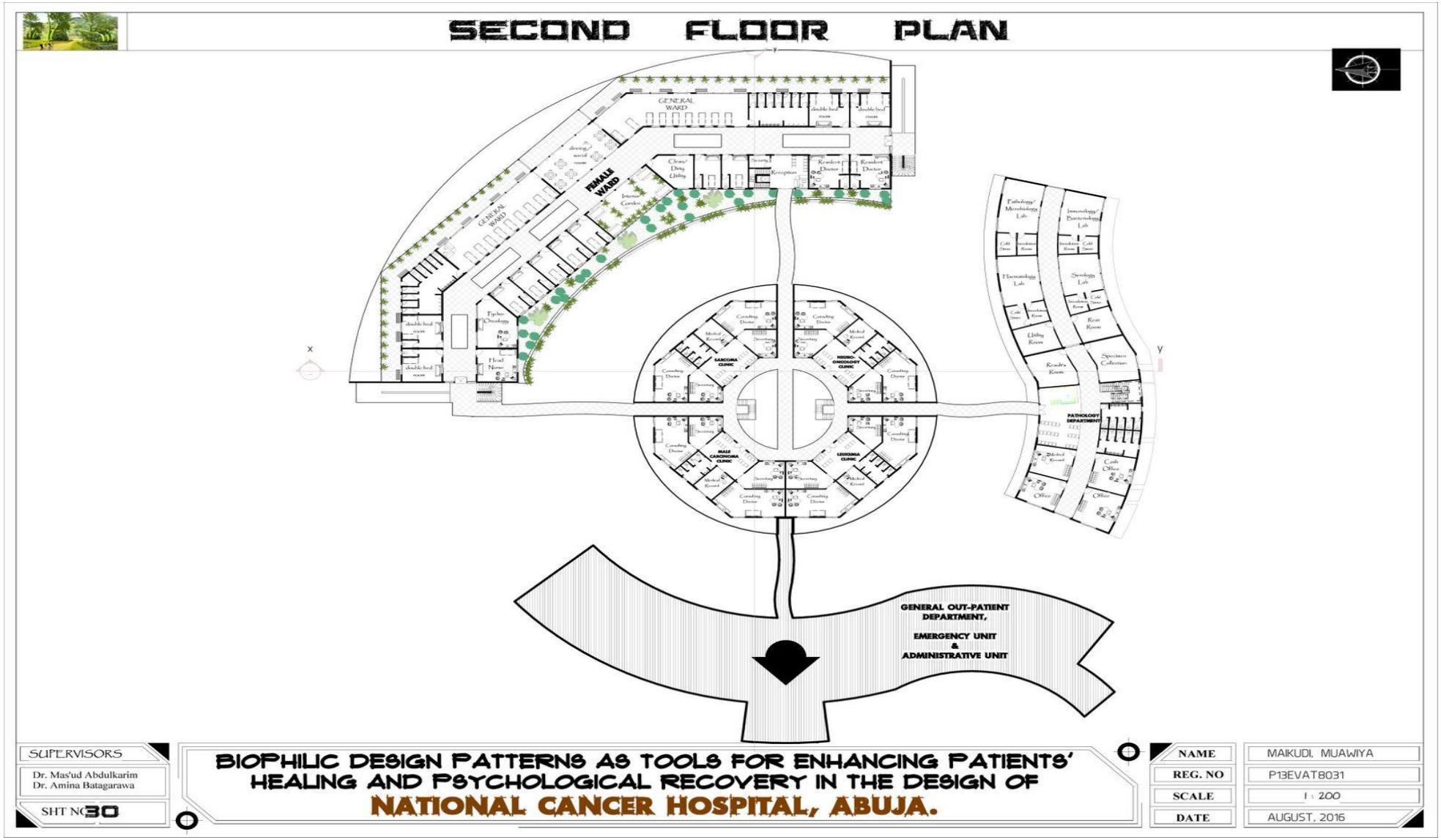
Appendix VI: Site Plan



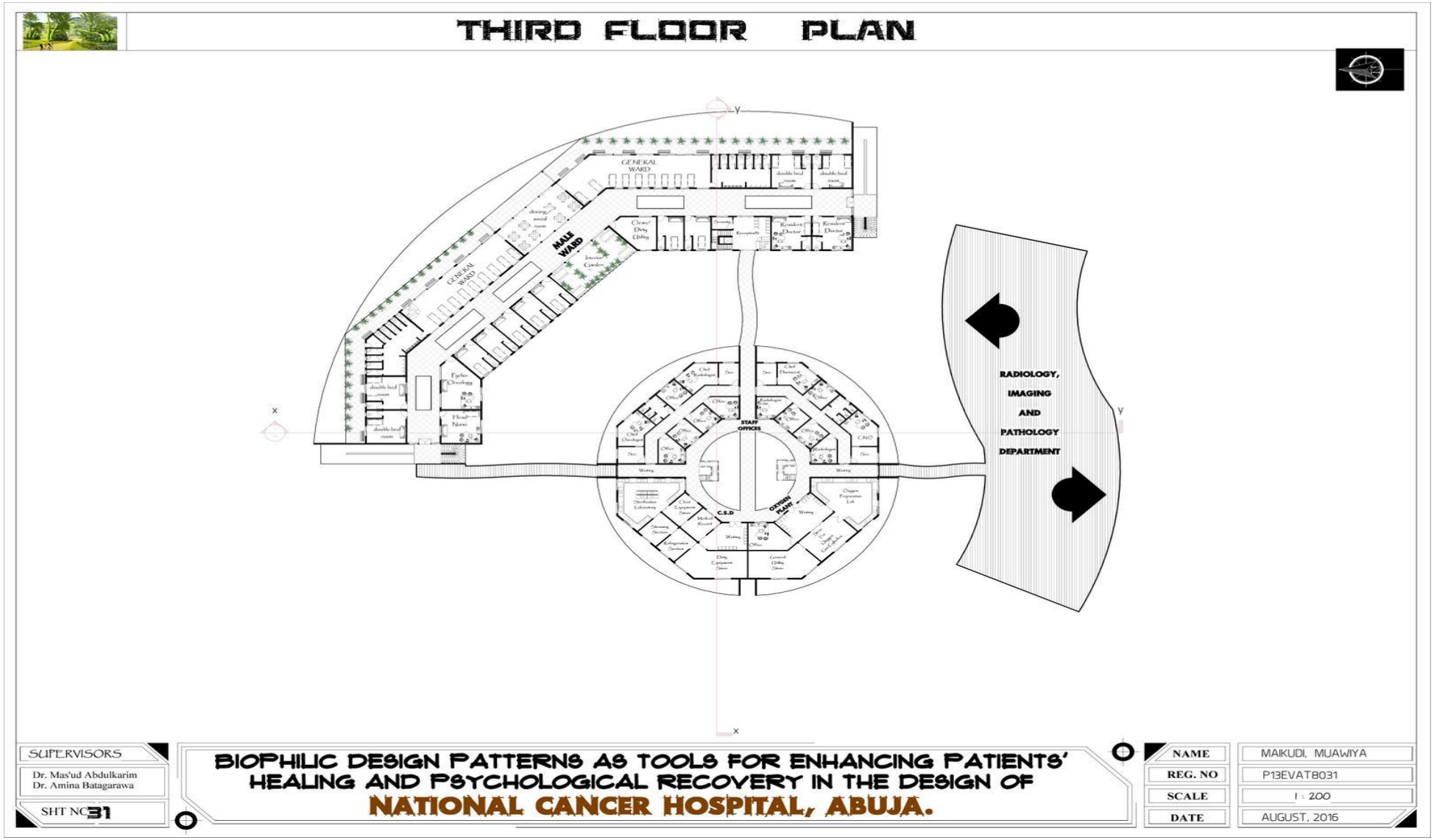
Appendix VII: First floor plan



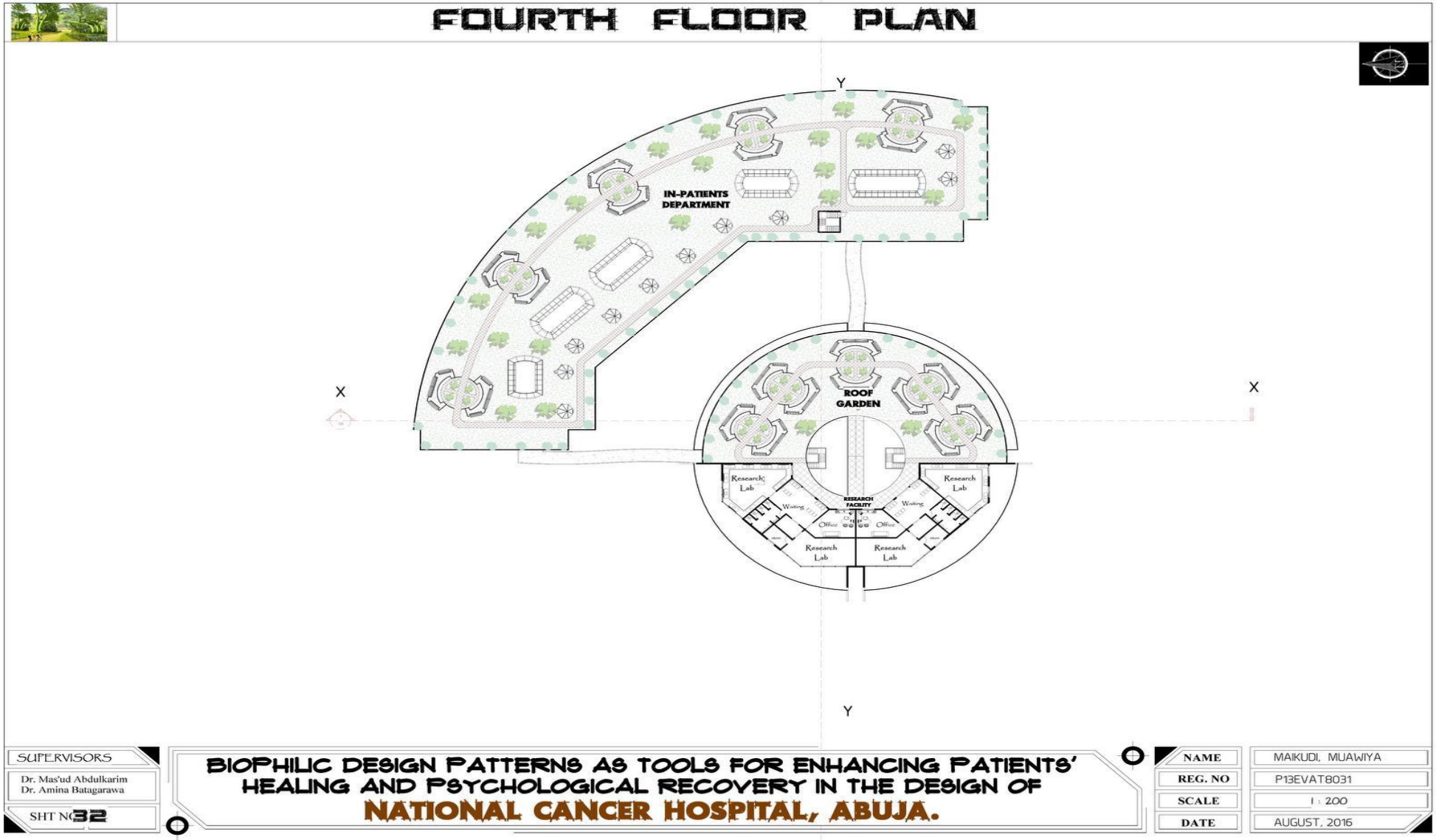
Appendix VIII: Second floor plan



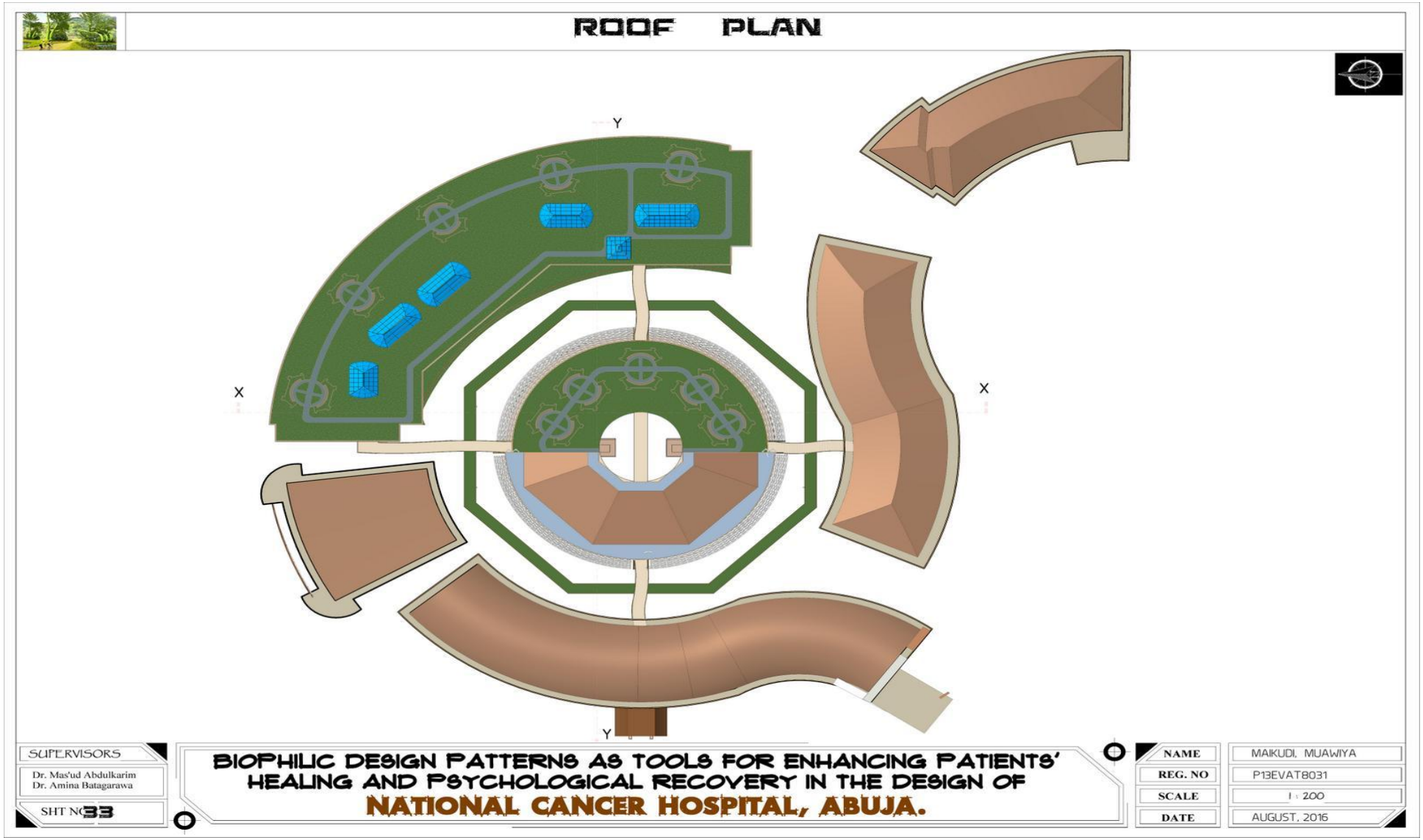
Appendix IX: Third floor plan



Appendix X: Fourth floor plan



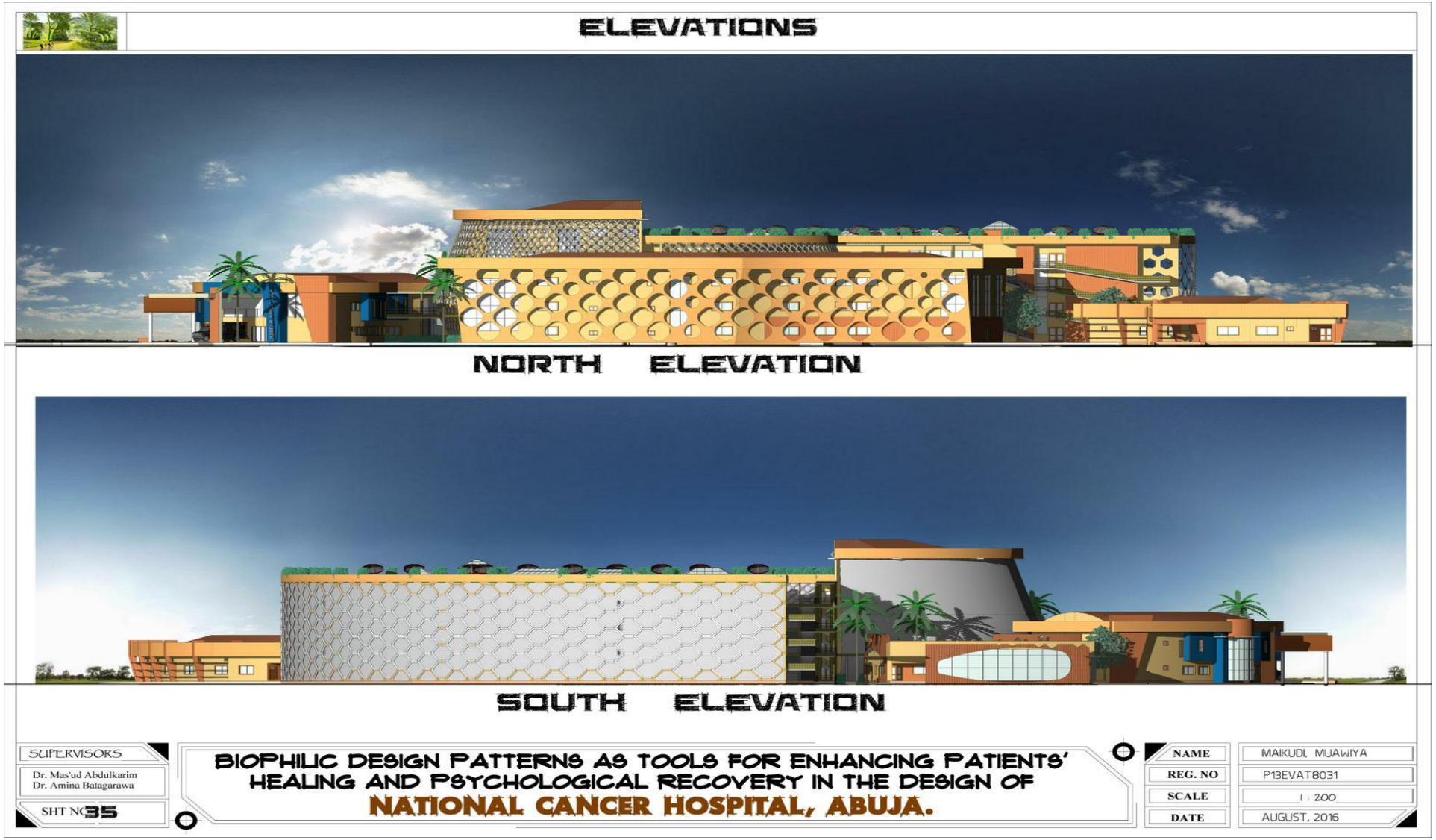
Appendix XI: Roof plan



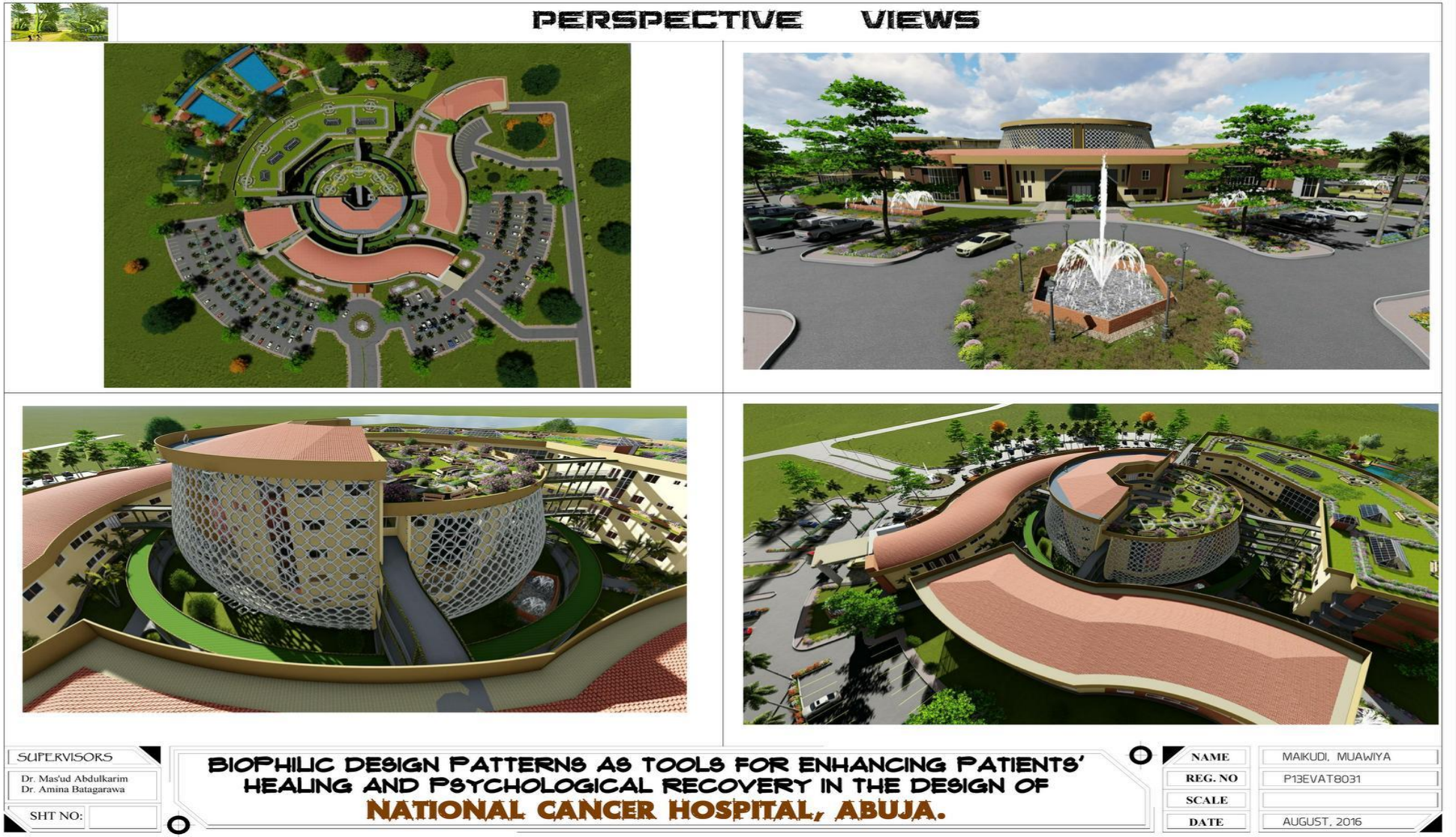
Appendix XII: Approach and rear elevations



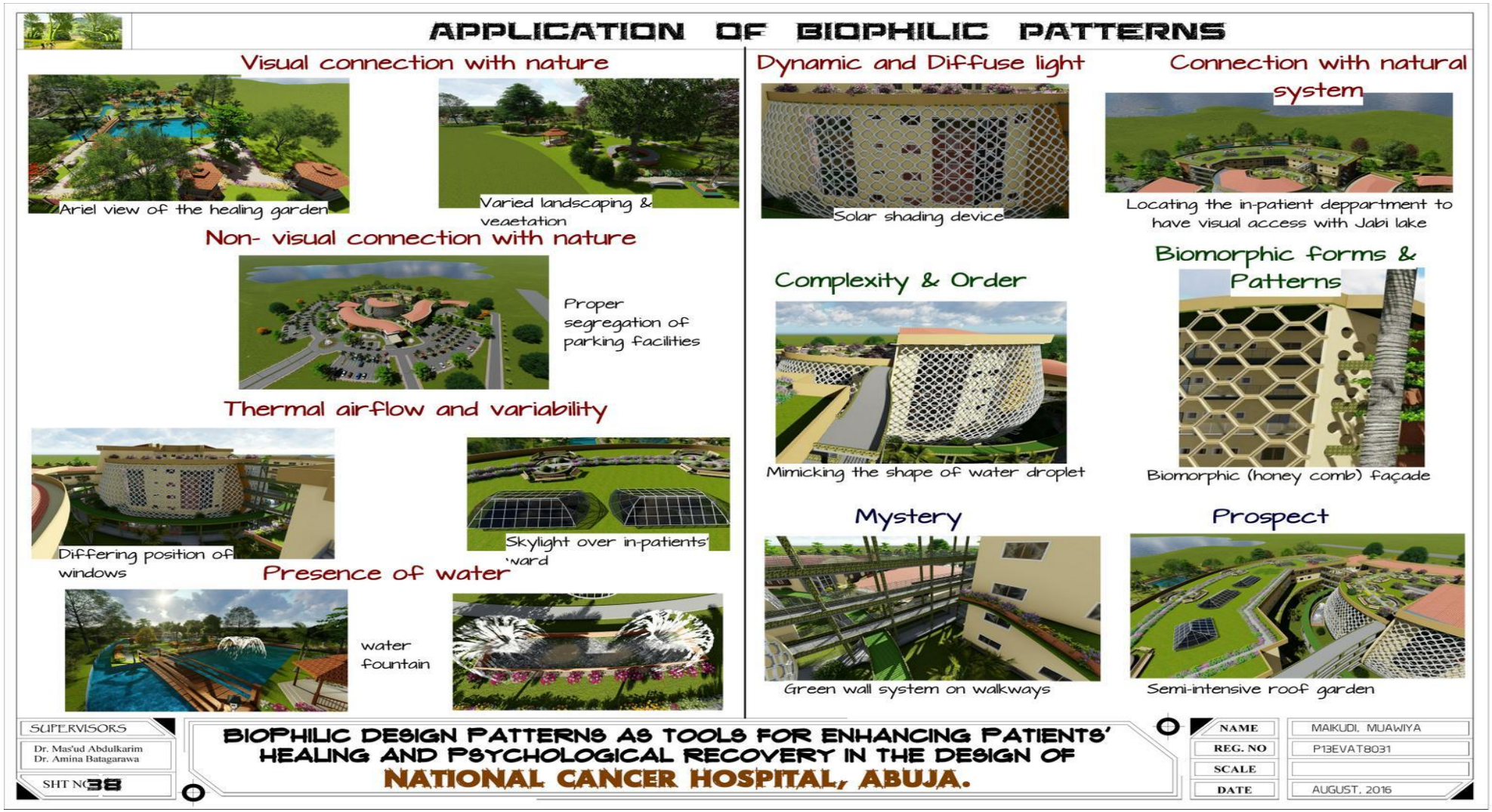
Appendix XIII: Sides eleavtions



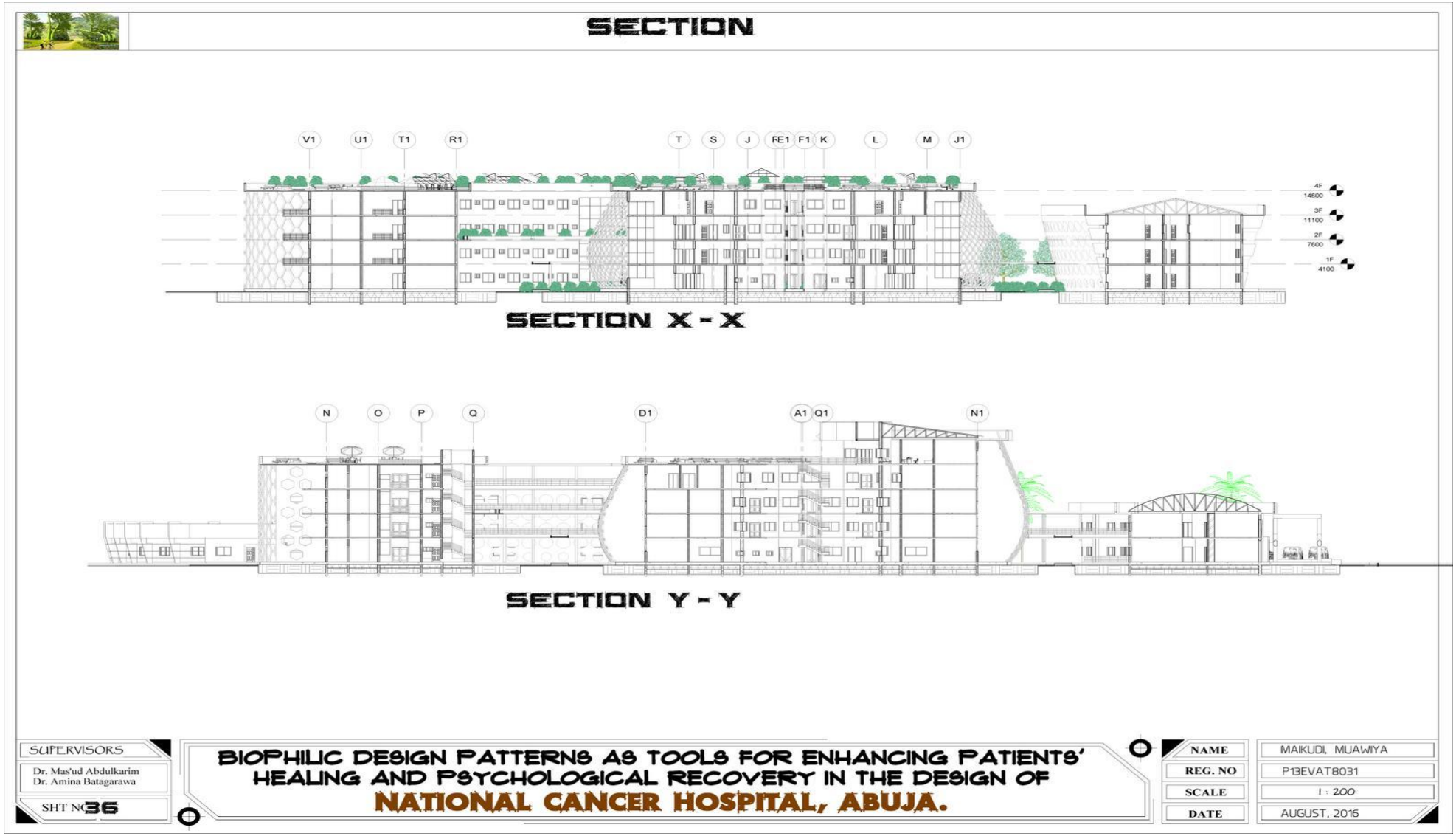
Appendix XIV: Perspectives



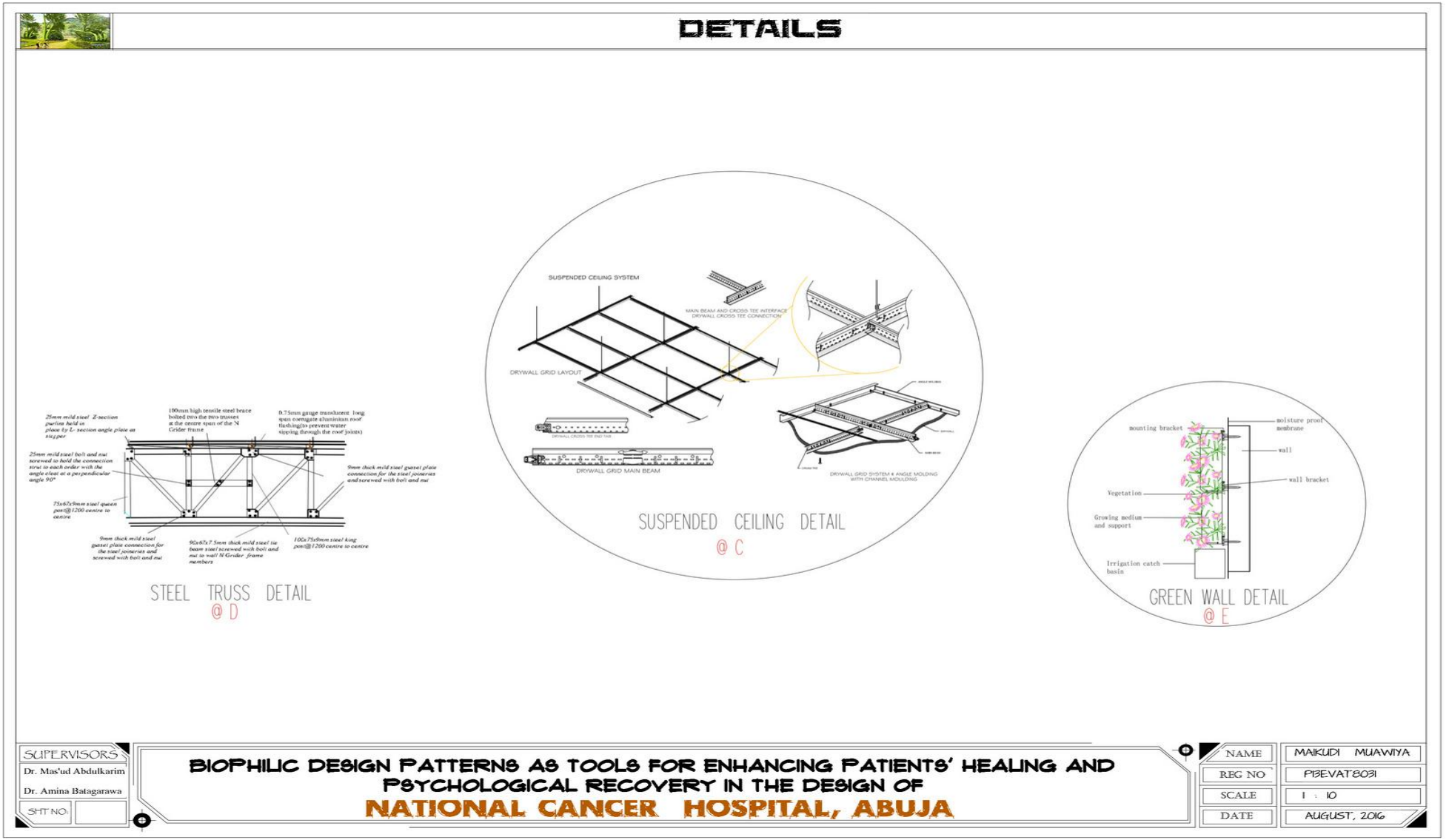
Appendix XV: Biophilic design patterns applied



Appendix XVI: Sections



Appendix XVII: Detail one



Appendix XVIII: Detail two

