APPROVAL PAGE

EFFECT OF LOW IMPACT DEVELOPMENT STRATEGIES ON RESIDENTIAL BUILDING SITE PLAN IN SATELLITE TOWN, LAGOS, NIGERIA

BY

AKAGWU MAMAJAUNKWUN

B.Tech., M.Tech. (Architecture)

ARC/03/1901

A THESIS IN THE DEPARTMENT OF ARCHITECTURE SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTERS OF PHILOSOPHY IN ARCHITECTURE OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, ONDO STATE, NIGERIA

2017

CERTIFICATION

(a) (By the student)

This work has not been presented elsewhere for the award of a degree, or any other purpose.

Candidate's Name: AKAGWU MAMAJAUNKWUN

Matric Number: ARC/03/1901

Signature……………………………………. Date…………………………………………

(b) (By the Supervisor (s):

I certify that this work has been carried out by Mr. AKAGWU MAMAJAUNKWUN in the Department of Architecture of the Federal University of Technology, Akure.

Major Supervisor's Name: **PROFESSOR J. A. FADAMIRO**

Signature……………………………………. Date…………………………………………

Co-Supervisor's Name: **DR (MRS) D. A. AYENI**

Signature……………………………………. Date…………………………………………

ACKNOWLEDGEMENT

Thank you Lord for all your graces which you have lavished upon me and for giving me even what I never dared to ask for. Thank you Lord for this precious gift of life, for my wife, mum, brothers and sisters whose companionship on this journey has been inestimable.

I thank Professor J.A Fadamiro the major supervisor of this thesis, and Doctor Mrs Dorcas Ayeni the co-supervisor for their alertness, guidance, patience, inspiration and motivation in carrying out this research work and throughout the course of my study. To my entire lecturers especially Professors Olutuah and Arayela, and the Head of Department, I say a very big thank you for your time and intellectual support. I can't forget to mention all my course mates that made the research wonderful and challenging.

I sincerely thank all those who contributed in one way or the other to the successful completion of this work, especially Fr. John Akagwu, SMA who took time out to read through the pages of this work, I am truly grateful. Words are not enough to express how grateful I am to all, but the blessings of our God and Father in your lives will complete my lack of words. May God bless you all, Amen.

DEDICATION

This work is dedicated to the blessed memory of my father, Alhaji Cyril Akagwu, whose whole life was a visible expression of the tender Fatherhood of our Eternal Father.

ABSTRACT

As population increases, peoples' relocation and spread from existing areas, pressures on building and undeveloped lands have become severe. There are signs of ineffectiveness in the design of most residential plots in addressing the thermal comfort, plot aesthetics and environmental quality. These are mainly due to the problems of design, planning, regulatory and administrative frame work within which physical development take place. The research is set at assessing landscaping and management issues in open spaces within approved setbacks of residential buildings in Satellite town, Lagos, Nigeria using Low Impact development approach. The research methodology focused on the effect of non-structural low impact development infiltration strategy on residential building site plans in Satellite town, Lagos, Nigeria. Research questionnaires were distributed to elicit information on socio-economic status, residential site status, and low impact development status in the study area. Perceptions from the residential site development as it relates to thermal comfort, plot aesthetics and environmental quality were also elicited. Qualitative data were also extracted from field observations and case studies carried out. Analyses were carried out using Statistical Package for Social Science (SPSS) Version 21 and Tobit statistical model. The study reveals that thermal comfort, environmental aesthetics and environmental quality of a residential site are largely dependent on setback distance and the state of setback ground. The study therefore concludes that Government's implementation of a certain area for unpaving on the residential site during site development, presented during approval and adequate monitoring during construction, will enhance the achievement of environmental sustenance and human wellbeing within residential plots.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF CHARTS

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

The rapid uncontrolled growth in many Nigerian cities has adversely affected land-use planning and resulted in poor environmental planning causing imbalance in the ecosystem of the environment and misuse of spaces (Ayeni & Olalusi, 2011). The results of this urban revolution are congestion, overcrowding and pollution, which are destroying the natural environments and eroding the quality of life (Fadamiro, 2010). Hence, it is imperative that building owners and developers maximize the restorative impact of site design and building infrastructure while meeting the projects other demands (World Building Design Guide Sustainable Committee, 2013). Site planning according to Lynch (1996) is the art and science of arranging structures on the land and shaping the spaces in between the structures. The residential building site is a simple environment expected to enhance and improve human welfare and environmental sustenance. But in recent times this has not effectively been the case in most areas in Lagos, Nigeria, rather artificial impervious elements especially concrete screed/ blocks has predominated open spaces within setbacks of residential buildings. This has consequently resulted to little or no space left out for natural landscaping and environmental sustenance.

The resultant effects of this unsustainable site development activity have led to development of heat islands and reduction in environmental quality and aesthetics, because the ecological sustainability of human settlements according to Scerri & James (2010) is partly a function of the relationship between humans and their natural, social and built environment. Sustainable site planning involves sustainable landscaping of outdoor building spaces which encompasses a variety of practices that have been developed in response to different environmental problems (World Building Design Guide Sustainable Committee, 2013). These practices also generate numerous environmental aesthetics and social benefits, including; adding park-like elements to yards and neighbourhoods, increasing habitat for biodiversity, offering recreational opportunities and reducing urban heat island effects. As an alternative, sustainable site design strategy has a direct correlation to enhance liveability and community aesthetics (Guillette, 2010). Landscaping is an art of planning the drives, walks, lawns, shrubs, gardens, flower beds and other site elements so as to form a beautiful setting for a building, giving the occupants a healthy breath, good surroundings and natural beauty (Benzu, 2010). It is essential for buildings to have aesthetically good and environmentally friendly surroundings and this can be achieved through the process of landscape development which involves the use of natural and artificial landscape elements (Fadamiro, 2010). Natural landscape elements are geographic features existing freely on the earth surface, collectively referred to as landforms and include, soil, caves, trees, hills, mountains, water bodies etc and they vary from one geographical location to another. Natural elements such as trees, shrubs, gardens, lawns and other landforms introduced into a geographical location by humans are built landscapes (National Geographic Society, 2017). Artificial landscape elements are components created by man, introduced into the natural environment, hence altering the natural environment (Benzu, 2010), and include buildings, driveways, walkways and all forms of man-made structures in the environment.

Coffman (2001) describes these landscape features as integrated management practices (IMP) and they form the building blocks of low impact development, with almost all the components of the urban environment having the potential to serve as the practice. Low impact development is a sustainable landscape concept that promotes designing with nature and involves the use of management measures known as integrated management practices which can be structural or non-structural. Low impact integrated management practices focus on minimizing impact to a site's pre-developed hydrology through non-structural practices and then providing treatment as necessary through a network of structural facilities distributed throughout a site (Washington State Department of Ecology, 2000). The concept of low impact development as perceived by Fairle (1996) is a development that through its low impact, enhances or does not significantly diminish environmental quality. According to Anne (2008), the concept is a design and developmental process geared towards a sustainable manipulation and utilization of natural water, vegetation and sustainable artificial landscape elements to achieve the goals of a nature friendly urban development. Maxey (2013) views the concept as a locally adapted, diverse and unique developmental concept based on renewable sources of an appropriate scale which enhances biodiversity, increases public access to open spaces, sustainable livelihood and coordinated by a management plan. Low impact development seeks to reduce or prevent adverse runoff impacts through sound site planning involving both structural and non-structural techniques that preserve or closely mimic the site's natural hydrologic response to precipitation, hence reducing the overall impact of land development on the environment (New Jersey Department of Environmental Protection, 2004). Non-structural low impact integrated management practices include minimizing site disturbance, preserving important site features, reducing and disconnecting impervious cover, flattening slopes, utilizing native vegetation, minimizing turf and maintaining natural drainage features.

Structural low impact integrated management practices involve the use of structural elements such as various type of basins, filters, surfaces (concrete, asphalt) and devices located on individual lots in a residential development or throughout a commercial, industrial or institutional site development (United States Environmental Protection Agency, 2000). Low impact development has multiple benefits such as protecting animal habitats, impervious surface reduction, site aesthetic enhancement and environmental quality improvement (Cabayi, 2016). Its site development techniques according to the United States Environmental Protection Agency (2000) can also play an important role in smart growth and green infrastructure land-use planning. The concept by virtue of its low environmental impact, may be allowed in locations where conventional development is not permitted (Fairle, 2009). This study focuses on the effects of the non-structural infiltration strategies of low impact development on the residential environment and users wellbeing.

1.2 Statement of Research Problem

John (2009) perceives that all built developments, from the small to the large, make an impact on their surroundings and the quality of residential developments in particular have long-term impacts both on communities and environment. Residential sites are expected to be functionally organised with natural and artificial elements capable of enhancing and improving human well-being and comfort. Most residential developments in Satellite town, Lagos, Nigeria, have been observed to have their set-back spaces predominantly treated with structural elements, mainly concrete or impervious paving with little or no site planning. This has consequently reduced the sustainable development goals of the residential plot, especially the aspects of environmental aesthetics and quality, increased heat island area and level of human comfort.

Some of the major essence of site planning is to ensure that developmental activities are organised in physical space with due consideration for the comfort, aesthetics, and environmental quality. Therefore, it is crucial to employ design solutions and strategies to help integrate effectively site developmental activities and environmental sustenance in the development of residential sites in Lagos, Nigeria.

1.3 Research Questions

The following are the research questions formulated to guide this study

1. How does setback of buildings in residential plots in Satellite town, Lagos, Nigeria affect the level of low impact development employed?
2. To what extent does the low impact development enhance thermal comfort of residential site users?
3. In what way does the low impact development affect site aesthetics?
4. How does the low impact development affect environmental quality of the residential development?

1.4 Aim and Objectives

The aim of the research is to assess landscaping of the open spaces within approved setbacks of residential buildings in Satellite town, Lagos Nigeria using Low Impact development approach, with a view of improving the thermal comfort, aesthetics and environmental quality of the residential plot. To achieve this aim, the research objectives are to;

i. examine the effect of setback distance on the level of low impact development employed around buildings in residential plots;
ii. assess the effect of low impact development on thermal comfort within residential plots.
iii. examine the implications of low impact development on residential plot aesthetics.
iv. evaluate the effect of low impact development on the quality of the residential environment.

1.5 Research Hypotheses

Hypothesis 1 (H_O1)

There is no significant relationship between setback distances and the level of low impact development employed in residential plots.

Hypothesis 2 (H_O2)

There is no significant relationship between low impact development of residential plot and thermal comfort within residential plots.

Hypothesis 3 (H_O3)

There is no significant relationship between Low impact development of setback space and residential plot aesthetics.

Hypothesis 4 (H_O4)

There is no significant relationship between low impact development of residential plot and environmental quality within residential plots.

1.6 Justification of the Study

The fast rate of plot development in residential estates in Satellite town, Lagos has been characterized by some impacts on the environment ranging from building development beyond setbacks and treatment of setback spaces mainly with concrete elements. According to Davis (2005), it has been unfortunate that this traditional development practices have put the environment at a risk, creating large tracts of impervious areas, thereby destroying infiltration and buffer zones. Major research publications on low impact development such as Deitz (2007), Anne (2008) and Dodds (2004) were focused more on the infiltration strategies of low impact development and its effect on site water management. Most of the authors and agencies researching and employing low impact development practices have their works focusing primarily on improvement, protection and management of site hydrological system. Effects on site aesthetics, biodiversity on site and human comfort are perceived as secondary issues. The scope of the researchers and agencies since the emergence of the concept of low impact development have been limited to regions in developed countries.

In 2015, the Urban and Regional Planning Division of the Federal Housing Authority of Nigeria circulated a publication on the approval guidelines and standards for residential sites. This was extracted from the building law manual of the nation and upgraded. The only clause relating to site setbacks is the approved distances to be left around residential buildings. There is no clause relating to achieving sustainable development goals through environmental sustenance of space within setbacks referred to as air space in the document. Kerry (2007) emphasized that it’s not all about writing on the benefits of the exterior natural spaces on human wellbeing, but how planners and designers should integrate the basic infrastructure required for today’s projects into a sustainable site plan. Hence there is a need to study ways of incorporating sustainable components into residential sites to enhance environmental quality and human wellbeing.

1.7 Scope of Study

The study is set to investigate the status of building setbacks in Newsite Residential Estate in Satellite town, Oriade Local Council in Amuwo-Odofin Local Government Area, Lagos state Nigeria. The study is focused on the non-structural infiltration strategies of Low Impact Development and is further restricted to open spaces within building setbacks of residential plots and between the plot fence and external drains.

1.8 Study Area

Satellite town in Lagos Nigeria is the residential community selected as the study area for this research. Satellite town was set up in the early 1960 by the Lagos state government to help low income earners own their own house with some areas in the residential development allocated to oil workers and private buyers. Satellite town is located along the Lagos-Badagry express road in Oriade local council development area in Amuwo-Odofin local government area in Lagos, Nigeria (Nwiro, 2010).

In 2007, the Lagos state government awarded a contract to rehabilitate the major roads in New-site residential estate in Satellite town, Lagos. The road rehabilitation project was completed in 2012 and this prompted so many land owners within the residential estate to commence their residential plot development. In less than four years which was between 2012 and 2015, about 60% of the undeveloped plots were developed with about 30% undergoing construction. New-site residential estate in Satellite town was selected as the specific study area for the purpose of this study because of its fast developing status. New-site residential estate is about ten (10) minutes' drive from the Lagos-Badagry express road and its approximately 877,458 m^2 in size. The residential estate is bounded on the north by the satellite town industrial layout, Ibeche River to the south, Navy town military barracks to the east and Satellite residential layout to the west. The residential estate though located in Lagos state is under the jurisdiction of the Federal Housing Authority of Nigeria (FHA). New-site residential estate is one of the fastest developing estates in Satellite town owned by private individuals under two (2) umbrella bodies known as the New-site residential estate Landlords Association and the Community Development Association. The estate is also well planned with well laid out road network. Although most of the minor street roads are untarred, they are constantly maintained by communal efforts of plot owners, Landlord's association and community development association. The estate's fast developing nature started in 2010 after the completion of its major road rehabilitation project which encourage many landowners in the estate to commence their plot development, which is one of the major reasons New-site residential estate was selected as the area for the study.

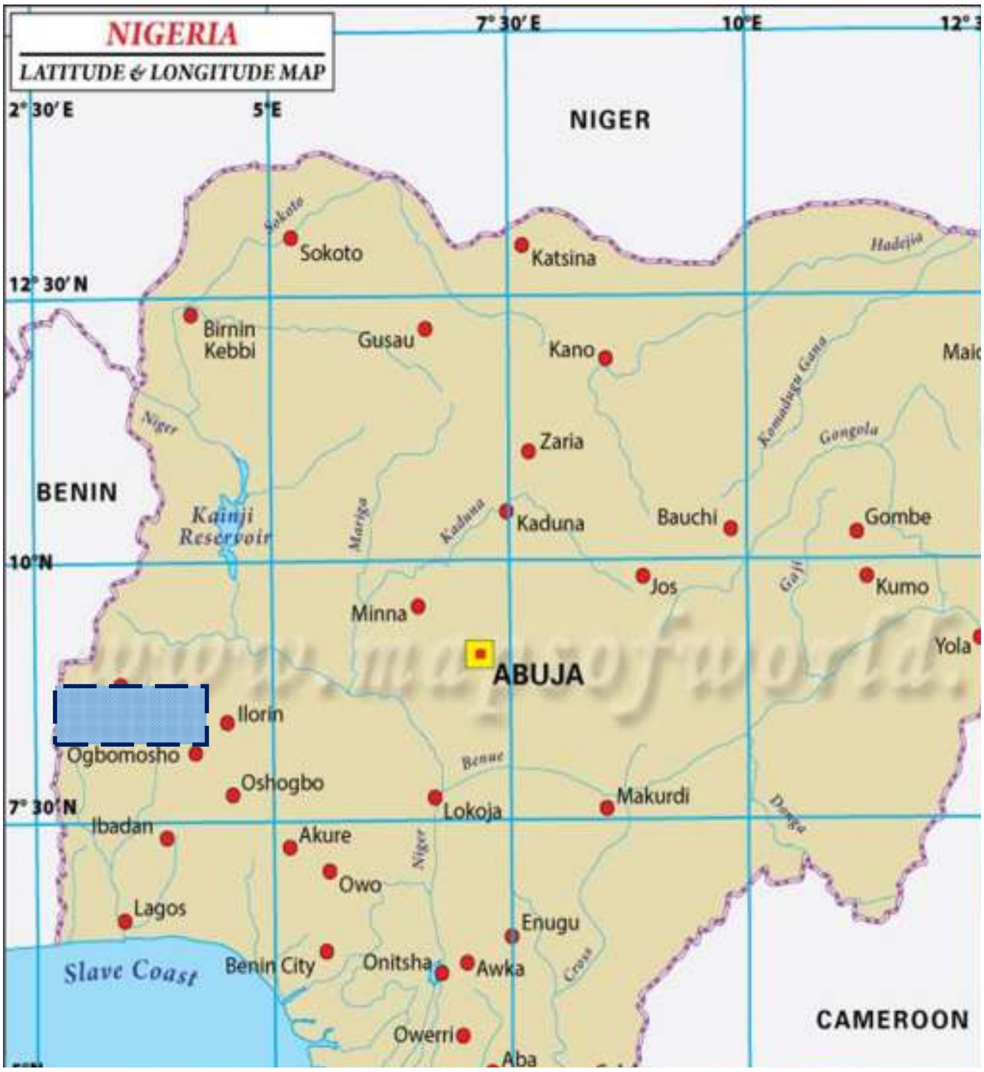

Fig 1.1: Map of Nigeria, with the location of Lagos State at the South-West Coastal end of the Country.

Source: www.mapsofworld.com, 2016

Fig 1.2: Map of Lagos State, with Amuwo-Odofin Local Government area at the Southern end of the State

Source: Mapsof.net, 2016

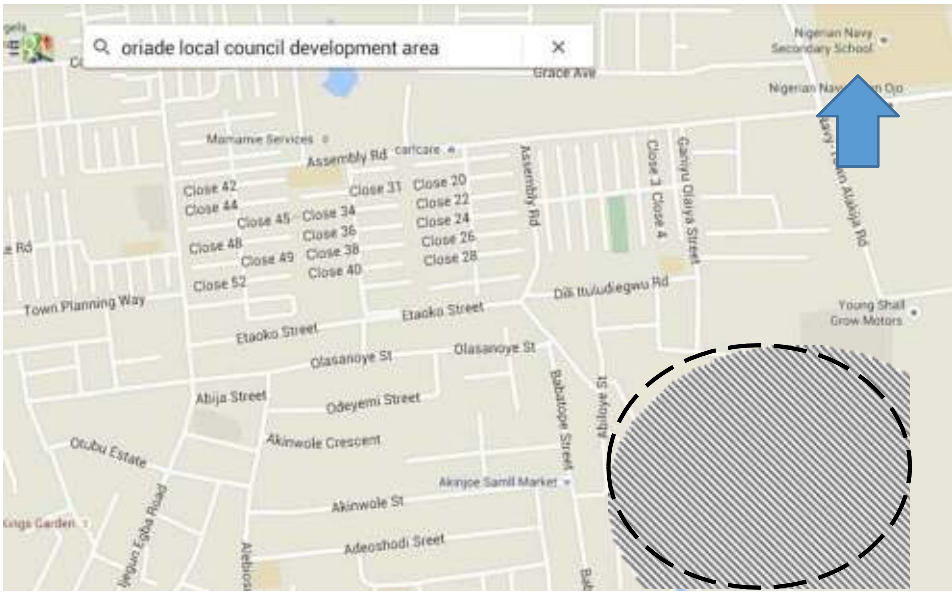

Fig 1.3: Map of Oriade Local Council Development Area, in Amuwo-Odofin Local Government showing New-site Residential Estate, Satellite town

Source: Google Map, 2016

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Site Planning

Muhammad (2015) perceives site planning as the organisation of the external physical environment to accommodate human behaviour involving the qualities and locations of structures, land activities and living things, thus creating a pattern of these elements in space and time, subject to future management and change. Site planning refers to the organizational stage of the landscape design process (Anomie, 2014). According to Bob (2011) a site plan should have least environmental impact while still meeting the client's project goals. It's sustainable if it meets project needs and budget and at the same time reduces environmental impact.

Simonds (1997) acknowledges that in traditional site planning, sometimes the effects on the neighbouring lands and waters were considered. In fact, comprehensive land use planning is a complementary process. An understanding of landscape at the regional scale is an essential prerequisite to smaller scale site planning and detailed landscape design. Conversely many of the criteria for land use in regional land use planning should be based on an understanding of construction and grading techniques used in site planning. The opportunity to build better sites, working with the landscape and with the environmental assets on a property, is actually not as difficult as one might imagine. Sustainable site planning and design helps reconnect people with nature and can blend the science of ecology with the art of design in any type of development (David, 2016).

According to the World Building Design Guide Sustainable Committee (2013) sustainable site planning is a site planning process, involving a whole system approach that seeks to minimize the development of open spaces, link natural areas, control erosion, reduce heat islands and minimize impervious external floor surfaces.

2.1.1 Site Planning and Design Process

Site planning and design process can be conceptualized as a design process involving a series of logical steps, with the aim of developing a solution to a problem (Science buddies, 2015). It is a multi-disciplinary problem-solving operation often involving architects, landscape architects and engineers, and frequently may require input from physical scientists as well to address environmental issues. The engineering design process, shown in the fig 2.1 below, presents a model to solve a problem by creating new products, systems, or environments.

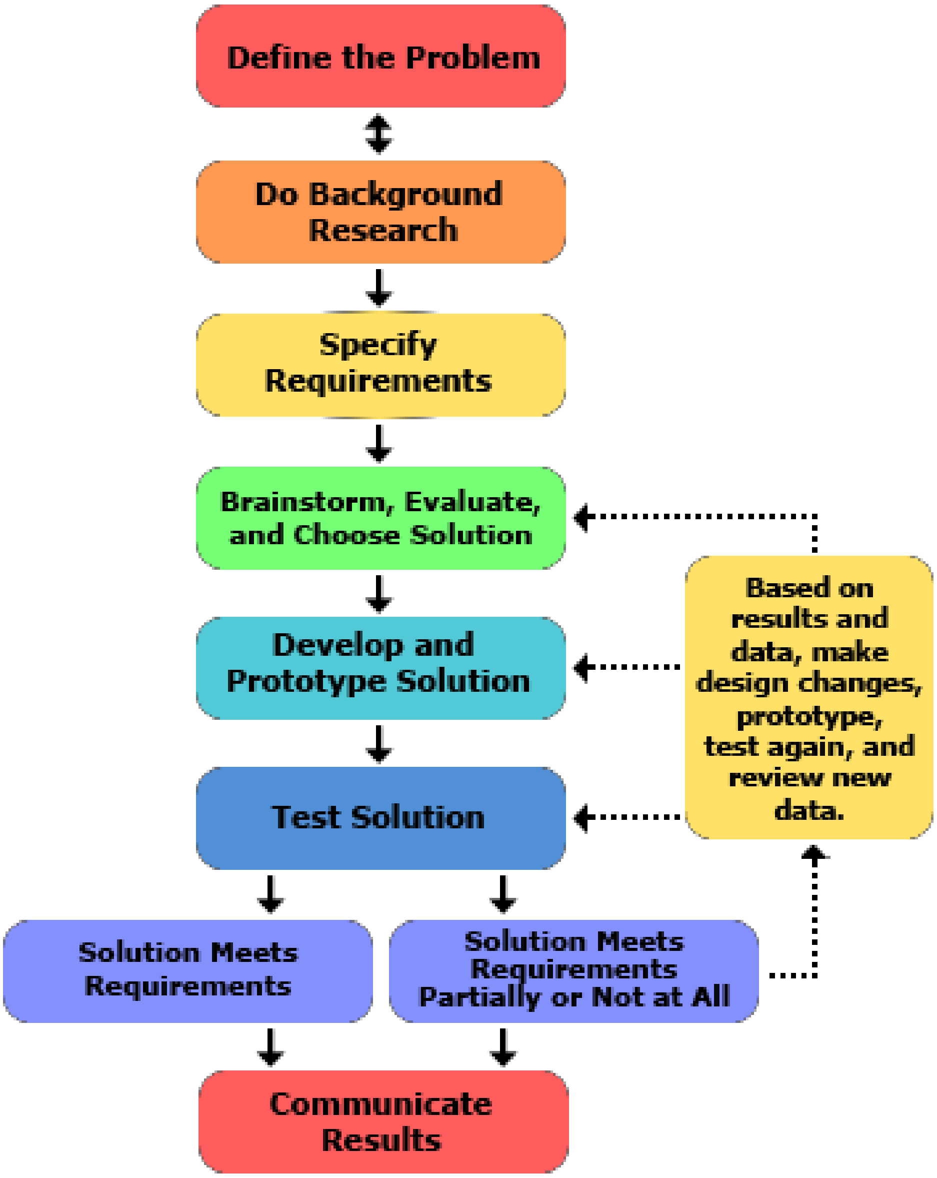

Fig 2.1: The Engineering Design Process

Source: www. Sciencebuddies.org

The process rarely moves in a linear fashion, instead designers jump back and forth between the steps as they move toward the final solution. Lynch (1996) outlines an eight-stage site planning cycle as presented in fig 2.2.

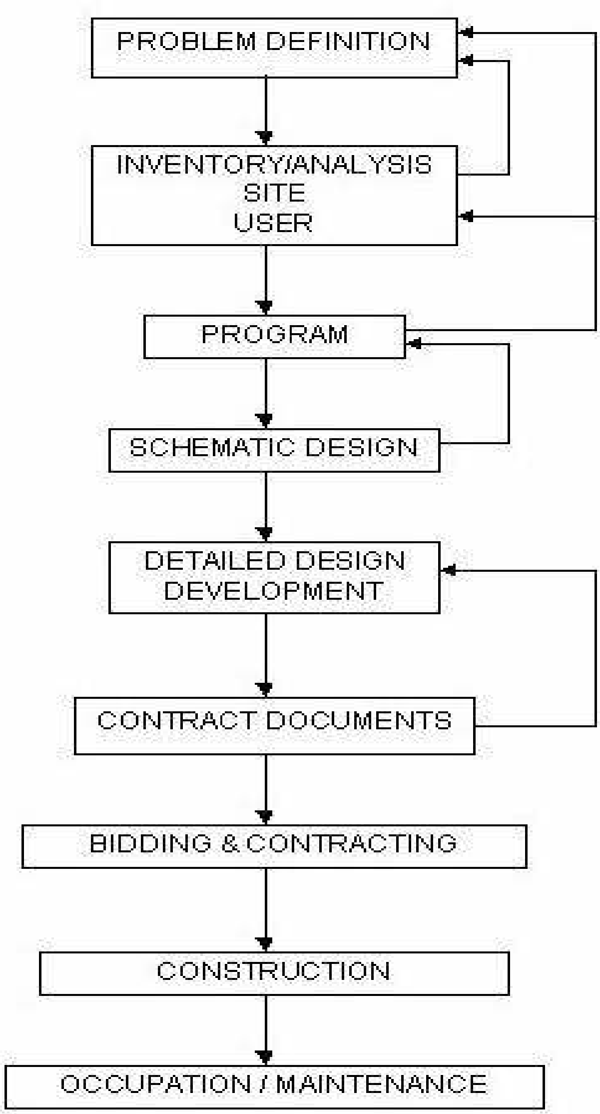

Fig 2.2: Kevin Lynch's Site Planning / Design Process

Source: Lynch, 1996

Irrespective of how many subparts are included, most process models can be divided into three general activities: Research (Program Development, Site Inventory); Analysis (Site Analysis); Synthesis (Conceptual Design, Preliminary Design, and Site Plan/Master Plan) (Steven, 1999).

2.1.2 Phases in Site Planning

i) Research and analysis phase

In site planning, as in other forms of problem-solving activity, the critical thinking process of research, analysis and synthesis makes a major contribution to the formation of design decisions. Research material may be gathered from existing projects, books, photographs, or experiments. Analysis of the site shall consider all existing features, both natural and man-made in order to determine those inherent qualities that give a site its identity. Emphasis should be made on the site's relationship with the total environment and its special values or potentials (xtain, 2016). According to Steven (1999), the major components under the research and analysis phase briefly involve the site being placed within its proper geographical, political, and functional context. This fixes the site in relation to adjacent land uses, community transportation patterns, utility and infrastructure availability, employment, commercial, cultural and recreational centres. It further involves depending upon the size and complexity of the site, this may be one or a series of base plans or maps that delineates and evaluates the physical attributes and constraints for the parcel of land. It will cover such items as; topography and slopes, geology and soils, vegetation, hydrology and drainage, microclimate, views, existing structures / infrastructure, and legal constraints.

ii) Programme development

The development of the programme is the bridging step between the analysis and the synthesis or design phases. Simonds (1997) noted that, in developing the program the designer responds to the client's initial statement of intent, modified on the basis of what he/she has learned at the end of the analysis phase. While the analysis is based upon a basic program concept, the potential of the site for development influences the planner's ultimate program recommendations. The program should include; a statement of goals that the project would achieve, a list of project objectives by which these goals will be accomplished and a list of project elements that will be included with a description or analysis of their interrelationships.

iii) Synthesis (design Phase)

Conceptual design is the very first phase of design, in which drawings or solid models are the dominant tools and products. The conceptual design phase provides a description of the proposed system in terms of a set of integrated ideas and concepts about what it should do, behave, and look like, that will be understandable by the users in the manner intended (ATA Engineering, 2016). The Design Team generates schemes based on information gathered from users and their field investigation. Schemes will be reviewed by all stakeholders and refined accordingly. This phase of the project defines the design parameters and the overall layout

(Yale School of Medicine, 2016). It also allows the designer to develop a preliminary cost estimate.

A master plan is a framework within which a location is developed or changed. A project master plan may be commissioned by a developer with a piece of land to exploit, or by an estate agent wishing to tackle a backlog of defects or alter its building stock to respond to changing requirements (Buro, 2016). These may include enlarged plan views of certain areas or components of a design, elevations and/or cross-sections of key elements, or three- dimensional views of the site design, are intended to clarify the client's understanding of the design.

iv) Construction details and specifications

Construction details and specifications are critical components of the design implementation package. The details specify the materials, dimensions, and construction techniques for the various design components of the site plan (Steven, 1999). Specifications define the qualitative requirements of materials and products to ensure that everyone understand the product requirements. The numbering and titling format used to organize construction information in specifications, the Construction Specifications Institute's (CSI's) Master format, provides a means of coordinating the information with a contractor's submissions, cost accounting systems, material filing, and requests for interpretation (Garry, 2000).

2.1.3 Environmental implications of site planning

The ecological sustainability of human settlements is part of the relationships between humans and their natural, social and built environments (Scerri & James, 2010). This broadens the focus of sustainable development to include the domain of human health. Fundamental human needs such as the availability and quality of air, water, food and shelter are also ecological foundations for sustainable development (White, 2013). Sustainable development through investments in ecosystem services can be a powerful and transformative force for sustainable development which in this sense extends to all species. Environmental sustainability requires society to design activities to meet human needs while preserving the life support systems of the planet. An unsustainable situation occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished (Lynn, 2014).

The concepts of ecological and sustainable design, which support this newer approach, are used interchangeably. "Sustainability allows us to provide for present needs, while promoting long-term ecological and physiological health and productivity". Sustainable design is then "the intentional planning and design of human ecosystems through the application of ecological understanding, to make conscious informed decisions concerning conflicts between human and ecosystem needs" (Motloch 1991). Steiner (1999) proposes an ecological planning model that attempts to use biophysical and sociocultural information to suggest opportunities and constraints for decision making about the use of the landscape. This model involves eleven interconnected steps as presented in the fig 2.3.

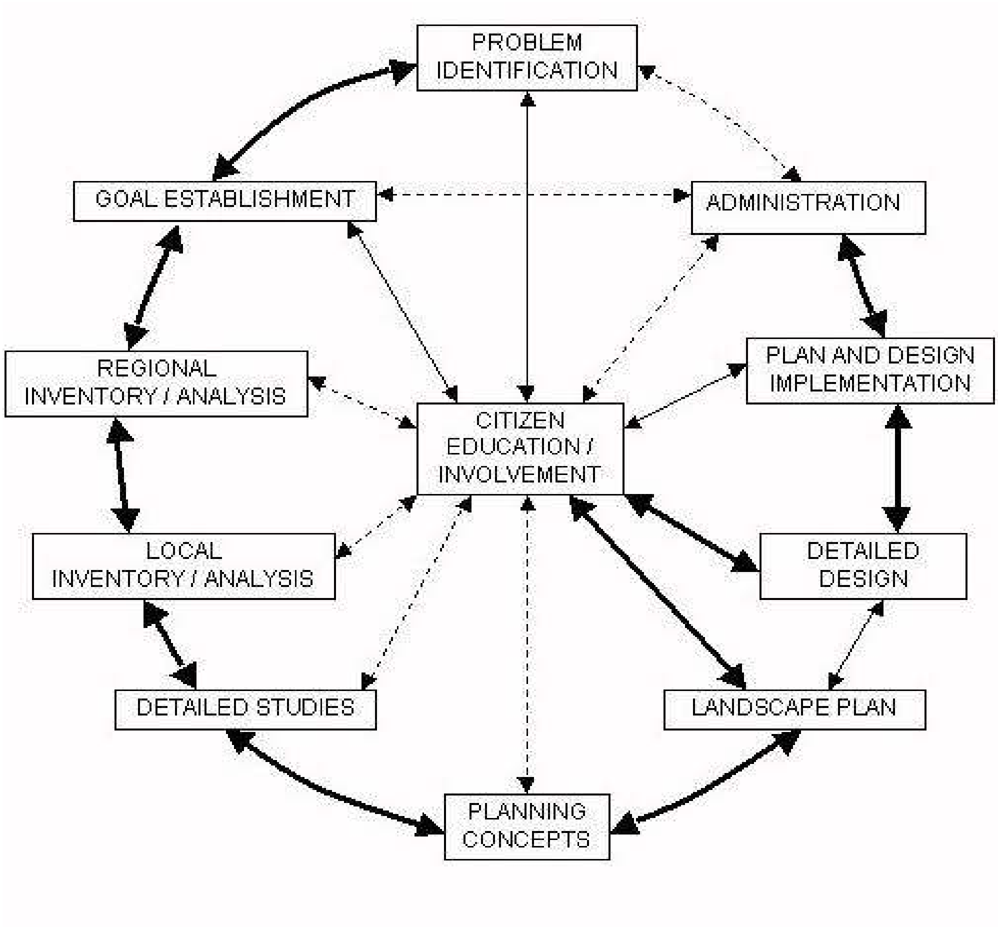

Fig 2.3: Frederick Steiner's Ecological Planning Model
Source: Steven, 1999

Steiner (1999) model clearly reflects a strong influence by placing particular emphasis upon ecological implications of physical planning and outlines the three scale levels; regional, local and site specific. He points out the disparity between the traditional American planning mentality and an ecological approach. Ecosystems can be viewed as fit for certain prospective land uses in a hierarchy. It is then possible to identify environments as fit for ecosystems, organisms and land uses. The more intrinsically an environment is fit for any of these, the less work of adaptation is necessary (Steiner 1999). Kerry (2007) emphasizes that during site planning and design process, it is important to study ways to integrate sustainable elements such as recycling materials, innovative storm water management practices sensitive to site layout, native (or naturalized) landscape materials and site lighting into a complete site package.

The site planning process is a series of logically sequential activities involving research and program development, site analysis and site inventory compilation, conceptual design, preliminary design and master plan development. This process can be perceived as an engineering design process prompted by a need, which forms the basis for the manipulation of the landed area through the series of strategic and sequential operations to achieve a product. The product in this case is the developed site that has met the need which prompted the site planning process.

The site (residential or any other type) is a subset of the global environment. The word global indicates that irrespective of the site boundaries defining individual sites, all sites and its components are connected. According to Newton’s third law of motion (Benjamin,2000), for every action, there is an equal and opposite reaction. Therefore, for every site development action on the environment, there is an equal and opposite reaction by the environment. This environmental effect can either be experienced by the site where the development action occurred or another site elsewhere within the globe. Though the site development elements (buildings and other landscapes) are affected by these reactions, the most affected is the reacting environment itself and humans. The lower the impact by the development, the lesser the environmental reaction.

Consequently, there is a need for the site planning process to logically involve low impact development concepts and strategies so as to achieve developed sites having less impact on the environment and meeting client’s requirement simultaneously. Hence achieve a low impact developed site, the landscape elements making up the site inventory in the site analysis stage should comprise mainly of elements capable of enhancing site’s natural occurrences. Natural landscape elements have capabilities of enhancing these natural site phenomena. Hence a site development process having these natural enhancing elements as major components of its site inventory have a high tendency of creating a low impact developed site.

2.2 Low Impact Development

As the economy and population continue to expand, the design, construction and operation community faces increasing challenges to meet the new demands for facilities that are accessible, secure, healthy, and productive while minimizing their impact on the environment (Rob, 2009).Alteration of natural hydrological systems by urbanization is generally translated by increased runoff rate and volume, decreased infiltration, decreased ground water recharge and base flow and deterioration of water quality in streams, rivers and shallow ground water (United States Geological Survey, 2016). These impacts along with adverse socio economic outcomes of urbanization have led to the necessity for more intelligent and smart planning of urban growth such as smart growth, water sensitivity planning, low impact development planning and other alternative ways to reduce negative impacts of urbanization on natural resources (United States Environmental Protection Agency, 2000).

Low Impact Development (LID) was pioneered in the early 1990s in Prince George’s county, Maryland, with the goal of decreasing the need for paving, kerb, gutter, pipe systems and inlet structures. This was achieved through the use of water features that could reduce the extent of hydrologic/ water quality effects of impervious surfaces with reduced infrastructure construction and maintenance cost (United States Department of Housing and Urban Development, 2003). LID is a sustainable site developmental process having minimal impact on the environment during and after the developmental process. It involves the sustainable manipulation of natural water and other natural landscape elements to achieve an environmental friendly developed site. The underlying basic principle of LID is to maintain post-development hydrology of a site close to the natural condition present before development occurs (Coffman, 2002). Low Impact Development (LID) capitalizes on the integration of infrastructure, architecture, and landscape in order to create a balanced, hydrologically functional and sustainable site. LID encompasses the use of structural devices (engineered systems) and non-structural devices (vegetated, natural systems). It uses a combination of these technologies, or a "suite of technologies," to maintain or restore the natural hydrologic functions on a site with the goal of reducing the impact of development. The goal is to structure the development of a site so that the pre-development conditions are not altered (Good, 2016).

2.2.1 Principles of low impact development

Low impact development is a green approach for storm water management that seeks to mimic the natural hydrology of a site using decentralized micro scale control measures

(Coffman 2002) by achieving water balance. According to Dod (2004), the principles of low impact development involves integration of storm water management strategies in the early stage of site planning, management of storm water as close as its source, promotion of environmentally sensitive designs, multifunctional landscapes and empowering communities for environmental protection through public education and participation.

According to Hunt (2010) the main goals of LID principles and practice include: Runoff reduction (peak and volume), infiltration increase, groundwater recharge, stream protection and water quality enhancement through pollutant removal mechanics such as filtration, chemical absorption and biological processes; which can be broadly classified into: Structural practices which consist of bio-retention infiltration wells/ trenches, storm water wetlands, wet ponds, level spreaders, permeable pavements, swales, green roof, vegetated filter/ buffer strips, sand filters, small culverts and water harvesting systems (Michael, 2007).

Non-structural practices which include minimization of site disturbance, preservation of natural site features, reduction and disconnection of impervious surfaces (i.e. elimination of curbs and gutters) strategic grading, native vegetation utilization, soil amendment and minimization of grass lawns.

Contech Engineered Solutions (2012) presents the principles of low impact development to include conservation of natural areas wherever possible, minimizing development impact on hydrology, maintaining run off duration from site, scattering integrated management practices (IMPs) throughout site and implementing pollution prevention, proper maintenance and public education programs. Anne (2016) presents the key elements of low impact development to include directing runoff to natural areas through enhancing infiltration and stream, wetlands and aquifer recharge, conservation involving preservation of native trees, vegetation, soils and natural drainage patterns. Other elements include small scale controls involving mimicking natural hydrology and processes, customized site design ensuring watershed protection, Maintenance, pollution prevention and education through reducing pollutant loads and increasing efficiency and longevity and finally educating and encouraging public involvement (Anne, 2016).

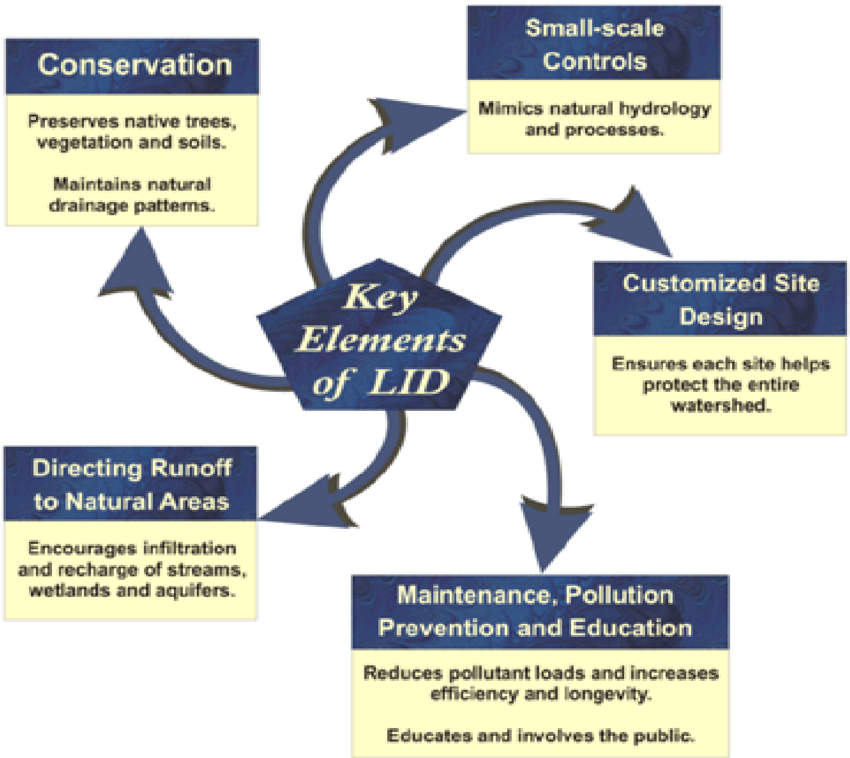

Fig 2.4: Key Elements of Low Impact Development

Source: Anne, 2016

2.2.2 Non-structural Low impact development site design strategies

As earlier mentioned, effective low impact development involves the use of non-structural development strategies to play significant roles in minimizing the impact of land development on the environment (New Jersey Department of Environmental Protection, 2004). Site design strategies for every design project address the arrangement of buildings, roads, parking areas, site features, and storm water management plans. Low impact development builds on conventional design strategies by exploiting every surface in the infrastructure, natural and hardscape to perform a beneficial hydrologic function. Some of the more prevalent site design techniques according to Sameer and Christine (2010) strategically employed on residential sites involves focusing on run off prevention through minimizing pervious ground cover, permeable paving, incorporation of green roofs, roof draining into pervious areas, tree preservation and designing landscape to create urban tree canopies. It further involves creating multifunctional landscapes, utilizing facilities that enhance infiltration, landscapes that reduce runoff, urban heat island effects, hence enhancing and improving thermal comfort, plot aesthetics and environmental quality of site developments. Non-structural low impact development practices can be grouped into four categories which include: vegetation and landscaping, minimizing site disturbance, impervious area management and time of concentration modification.

The management of existing and proposed vegetation at a land development site can significantly reduce the site’s impact on the environment. Pervious vegetated areas reduce runoff volumes and peaks through infiltration surface storage and evapotranspiration. Vegetated areas also provide a surface for ground water recharge, particularly during dormant and non-growing seasons.

Minimizing land disturbance at a development site can be practiced during all phases of a land development project which can help reduce run off volumes and pollutant loads on the environment hence preserving existing site areas. This begins during the project planning and design phases with the goal of limiting clearing, grading and other land disturbance necessary for building structures. The New Jersey Geological survey recommendation for low impact development include deconcentrating flow, minimize grading, building with landscape, not altering natural drainage areas, minimizing imperviousness and minimizing soil amendments.

Pervious paving materials can be used at many site locations to replace standard impervious pavement. These locations may include parking spaces, driveways, access roadways, and sidewalks. Pervious material can include pavers (interlocking concrete blocks or bricks), porous pavement (concrete or asphalt), gravel, and reinforced lawn. While brick pavers, concrete block pavers, and gravel are themselves impervious, their use can reduce impervious areas by providing gaps between individual pieces through which runoff can reach a pervious base course and/or subsoil. Turf blocks (open cells made of concrete, plastic, or composite materials that are filled with soil and planted with grass) may also be utilized to replace traditionally paved areas. Porous concrete and asphalt are generally considered fully pervious and may be viable options for areas that need to be fully paved ((New Jersey Department of Environmental Protection, 2004).

2.2.3 Infiltration strategy of low impact development

A portion of water that falls as rain or snow on the soil anywhere in the world moves vertically down into the subsurface soil or rock. This vertical downward movement of water into the subsurface soil is referred to as infiltration and can only continue if there is room for available additional water in the soil (Hogan, 2010). Some may infiltrate deeper, recharging ground water aquifers. Factors affecting infiltration include; Precipitation volume, Base flow, soil characteristics, soil saturation, land covers, slope of land and evapotranspiration (United States Geological Survey, 2016).

Some Low Impact development infiltration practice used in modelling according to (Brander, 2004) include; spreading runoff over lawns, improving infiltration capacities of lawns and directing roof top runoffs into rain garden. It further includes spreading driveway and side walk runoffs over lawns, reducing street width, directing street runoff into grass swales and directing runoff into rain gardens Dietz (2007) focuses on other forms of Low impact development Infiltration practices such as bio-retention cells which have been effective in retaining large volumes of runoff and pollutants on site and constantly reduced concentration of certain pollutants such as metals. He further focuses on porous pavements and green roofs which have been extremely effective in infiltrating storm water runoff.

2.2.4 Low impact technologies

The following examples addresses ways to determine the goals for on-site reuse of rainwater and water conservation and determine which level of on-site reuse and water conservation is consistent with project objectives. Anne (2008) proposes a list of suitable LID technologies for the different water conservation levels. Level one involves the distribution Storm water runoff using open and vegetated areas to increase infiltration and reduce the amount of storm water that enters the storm drains, through sheet flow into rain gardens, bio-swales, bio-retention cells, tree box filters, soil amendments, structural soil, native and sustainable ornamental plants.

Level two involves replacing hardscape materials with permeable materials through construction of sidewalks, parking bays, and internal alleys with materials, such as permeable concrete or green grids, that allow water to infiltrate. It further involves sloping roads in the directions of the parking lot islands, through permeable paving, curb-less parking lot islands, and porous concrete parking bays.

Level three involves recycling rainwater and run-offs; this level uses above-ground LID devices to channel and collect rainwater from roofs, and uses sub-surface facilities to treat and collect runoff from roads and sidewalks. The recycled and stored water is used for irrigation and other non-potable purposes. The devices are integral with the buildings and infrastructure and include disconnected roof drains, cisterns, sub-surface storm water retention facility (below parking lots), rooftop channels and rain barrels.

2.2.5 Benefits of Low Impact Development

To the developer, low impact development provides new options for site layout/ storm water facilities and recreation, reducing land clearing and grading cost and consequently reducing potential infrastructure cost. It further reduces storm water management cost and help produce more attractive neighbourhoods that sell faster (Low Impact Development Centre, 2007). For the environment, low impact development preserves integrity of ecological and biological systems, protecting water quality and impacts to local terrestrial and aquatic plants and animals by reducing pollutant loads. It further reduces flooding potential and preserves trees and natural vegetation (United States Environmental Protection Agency, 2000).

The main research on the concept of environmental sustenance and human wellbeing through low impact development of residential and other developments started in 1999 in Maryland, United States and was piloted by Prince George's county Municipal Council. The successes achieved from the application of its principles of site water management brought about more research works by different independent researchers, institutes, councils and agencies. Since its emergence, Low impact development research works have been carried out by the United States Environmental Protection Agency since 2000 focusing on different regions in the United States. In 2012, the Richmond Regional Planning District Commission uploaded a publication of successful low impact development strategies employed in different areas in the United States (Richmond Regional Planning District Commission, 2012)

Low impact development as perceived by different authors and agencies is a site development process in which the basic problem prompting the site planning process is the maintenance of a hydrologically balanced site. It involves enhancing and managing water movement occurrences on a site, integrating environmental concerns with land development. The concept is broadly achieved through two different practices which are the structural practices and the non-structural practices.

2.3 Relevance of Physical Planning Practice in Residential Site Plan Development in Lagos, Nigeria

Planning is a rational, goal oriented, future oriented and an action oriented process (Okoro, 2014). Physical planning in Nigeria, can simply be perceived as "Land use planning", "Town and country planning", "Urban and Regional planning" and this relates generally to the use of land or the spatial expression of the desired form of social and economic development to be translated on the ground. Physical planning is a comprehensive system of related processes through which plans and policies are developed for enhancing the quality of the environment and the lives of the inhabitants (The Urban and Regional Planning Law Decree 88, 1992).

Development in general terms connotes a planned process of change in the right direction which have some implications for livelihood (Onibokun, 2007). The Urban and Regional planning law (Decree 88) of 1992 is the physical planning law instrument that guides the legal and administrative procedure in the operation of physical planning and implementation with development documents. It operates based on the use of land for physical planning purposes hinged on the provision of the land use Act of 1978. The law provided for the establishment of three agencies which are the National, state and local government agencies for the administration of physical planning activities in Nigeria.

The physical planning law document spelt out broadly the major components of physical planning that contribute as veritable tools or instruments to achieving orderliness and sustainable development for the welfare of the citizenry in Nigeria. Development control is the regulation of the detailed aspect of physical planning about which precise guidance cannot be given in the master plan and sector plan (Federal Ministry of Works & Housing, 2001). It is a process of monitoring and enforcing lay down rules and measures of standards in the development of land to achieve the goals of frictionless circulation, balanced and harmonious development or growth to ensure protection of individual's right with others, for a sustainable development. It is simply a tool to regulate land-sub-division, using planning standards as benchmark in all physical plans. For every development, guidelines and standards are set up for implementation to avoid creating chaos to the environment and other users (Ademola, 2001).

Development control Departments check new developments, fencing, demolitions, repairs and renovation, change of design, change of land use or purpose clause, contraventions, illegal occupation and revalidation of development permit, as well as certificate of fitness and habitation. The monitoring and routine check on the site is to see that the developer is not illegally developing, has a development permit and is building according to the approved standards. Zoning is another consideration if not checked, people could build under or within setbacks from an electric high tension wire or close to oil pipeline which are dangerous (Federal Ministry of Works & Housing, 2001).

Site Design specifications for residential plots according to the Federal Ministry of Works and Housing, URDD (2015) include:

a. Site location plan showing existing or proposed adjacent development or named road sufficient to locate site.
b. Minimum set back from plot boundary line to building line from minor road to be not less than 6m
c. Minimum set back / air space on either side of building to plot boundary line to be not less than 3m.
d. Minimum set back/ air space at the rear of building to plot boundary line to be not less than 3m.
e. Packing layout indicated and details of land use analysis provided.

Despite the establishment of the different agencies set up by the government at different levels to ensure sustainable growth in the country, residential site planning and development is still facing series of issues in the city of Lagos. These issues range from lack of compliance to set back standards by developers, poor and unsustainable treatment of spaces within setbacks, poor and unsustainable treatment of spaces between fence and external drainage system, etc. The essence of site planning is to ensure that developmental activities are organised in physical space with due consideration for the protection of human wellbeing, safety, comfort, aesthetics, energy conservation, social equity and environmental quality.

Establishing environmentally functional sites in the city of Lagos are encountering issues and at the centre of these issues are questions of who is responsible for ensuring environmental quality of residential sites, how can residential sites be made more environmentally friendly and what concepts and ideas can be implemented to enhance environmental friendliness and human wellbeing. According to Okoro (2014), the manifestation of these ineffectiveness in the site sustainability of most residential plots to a large extent is due to problems of design, planning, regulatory and administrative frame within which physical development takes place. This study focuses on the non-structural practices which basically involves reduction of paved areas within site setbacks of residential buildings and other site developments, subsequently conserving and introducing nature into unpaved areas. The basic phenomena focused on in this strategy is the infiltration process and the major landscape component involved is the site soil. This component forms the basis of support for all naturally existing landscape elements on the site. This component further determines the survival and variety of imported natural landscape elements on the site. Therefore, the manipulation of the soil component of residential site goes a long way to determine the level of environmental impact on the globe by the site development.

Hence the site planning and development process as a means to achieving low impact developed sites should incorporate concepts and strategies to enhance soil processes which is the basis of environmental sustenance and human wellbeing. The non-structural infiltration strategies of low impact development and its effects on the residential environment and inhabitants is essential in achieving functional residential sites, hence the focus of this study

CHAPTER 3

3.0 RESEARCH METHODOLOGY

This section discusses the methodology used to investigate the research questions through the research design, research population, sampling technique, sampling frame, sample size, data collection procedure and analysis.

3.1 Research Design

The research design is the framework within which the research was conducted which constituted the blue print for the collection, measurement and analysis of data. The research is designed to assess the impact of functional residential site planning on user's comfort, site aesthetics and environmental quality through non-structural low impact development infiltration strategies. The study employed mixed methods research approach. Approaches such as field study methods which include observation and case study (qualitative data) were combined with field surveys (quantitative data). Under the qualitative methods, structured observations were made to assess external site setback situations of residential plots along major roads and selected minor street roads within the residential estate. Case studies of some selected plots were also done to assess site set back situations as it relates to level of employment of low impact development. For the survey approach, a questionnaire was designed that comprised close ended questions and administered with the aim of gathering subjective data from residential plot users. Details of the variables studied are as summarized in tables 3.1 and 3.2 .

Table 3.1: list of quantitative research variables

Component	Variables	No. of Variables
Socio-Economic Characteristics of respondent	Plot ownership, plot size, Age of respondent, Education status and employment status	5
Residential Site plan status	Site design, parking space, open natural space, set back distances, site plan approval and development monitoring	6
Low impact development status	Nature preservation, nature introduction, site setback state, nature of paved area, nature of unpaved area	5

Table 3.2: list of qualitative research variables

Component	Variables	No. of Variables
Residential Site plan status	Area of residential Site, set back distances around residential building.	2
Low impact development status	Site setback state, nature of paved area, nature of unpaved area	3
Low impact effects on residential site	Thermal comfort, site aesthetics, environmental quality	3

3.2 Research Population

The research population for this study is all the residential plots in New-site residential estate in Satellite town that are accommodated. A total of 342 residential plots are accommodated either as personal ownership or rental ownership as at the time of this study, as presented in the fig.3.1. For the purpose of this research, the study area was divided into three (3) sectors according to the residential plot development pattern. These sectors include community road sector with a research population of seventy-one (71), David West sector with a research population of one hundred and forty-one (141) and David East sector with a research population of one hundred and twenty-eight (128).

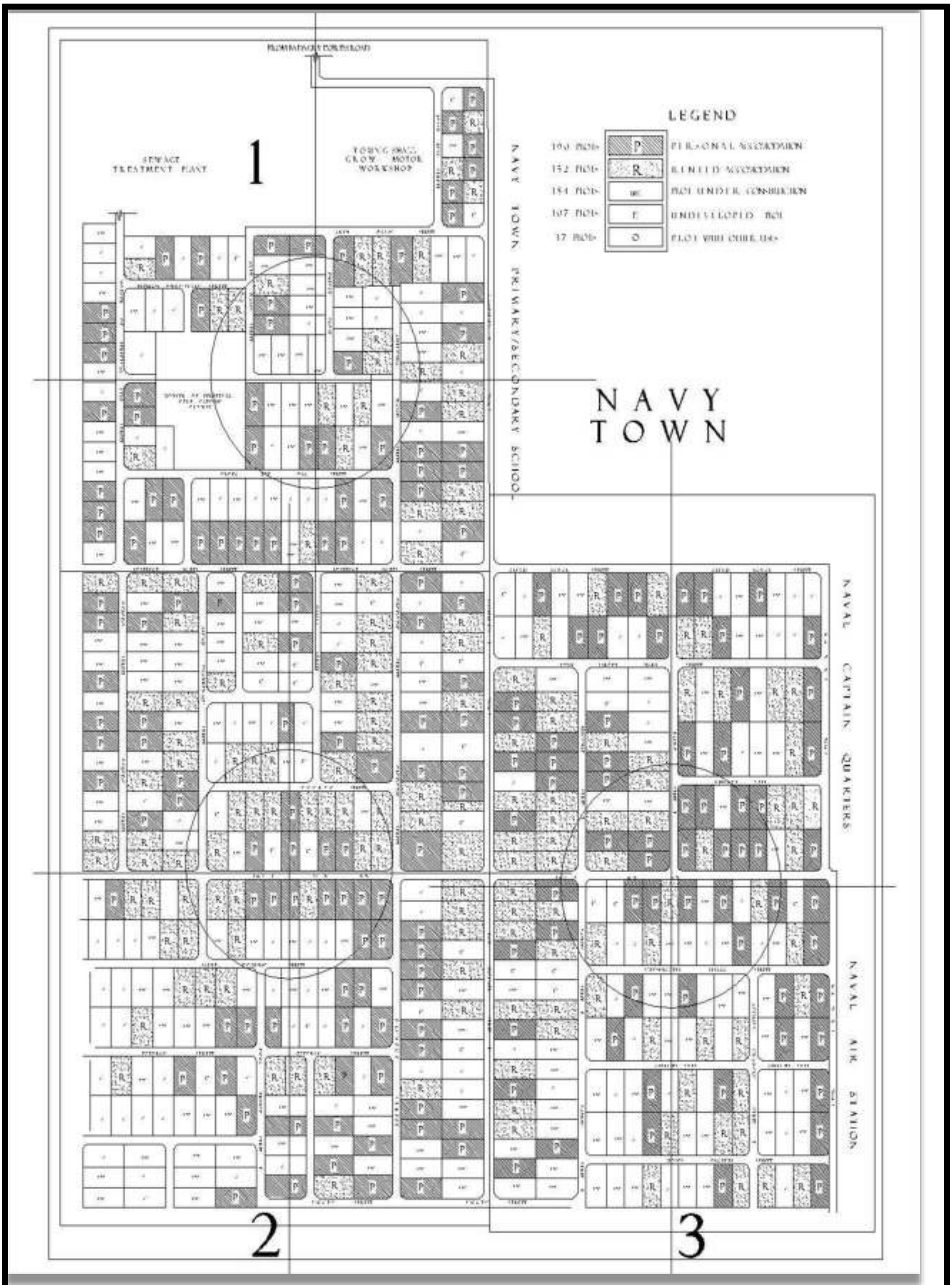

Fig 3.1: Layout showing the Research population divided into 3 sectors
Source: Author's Field work, 2016

3.3 Sampling Frame

The sampling frame for this research comprise of a list of all the streets in each research sector in New-site residential estate, with the number of accommodated residential plots in each street as presented in tables 3.4, 3.5 and 3.6 respectively. From the sampling frame, there are 73 accommodated residential plots in sector 1 representing 21% of the total research population, 141 in sector 2 representing 41% of the total research population and 128 in sector 3 representing 38% of the total research population. It is from this list and according to these percentages the sample size was derived and apportioned.

3.4 Sampling Size

The research sample size was calculated using a sample size calculator according to Creative Research System (2012) at a confidence level of 95% and confidence interval of 5 with a population size of 342. A sample size of 181 was generated by the sample size calculator which was compared with the sample size figure according to Krejcie & Morgan (1970). For the purpose of this research, a sample size of 182 was used. The samples were proportionally selected from each of the research sectors to make up a total of 182. This gives 21% from sector one with a total of 38 samples, 41% from sector two with a total of 75 samples and 38% from sector three with a total of 69 samples as presented in tables 3.4, 3.5 and 3.6.

3.5 Sampling Technique

The study adopted a probabilistic sampling technique known as census inquiry (Kothari 2004) in which the number of questionnaires administered to respondents equals the sample size. Stratified and random sampling methods were used for the study. The estate was divided into three (3) sectors and the sectors divided into streets as earlier presented in the research population and research frame respectively.

Random sampling technique was employed to select the number of residential plots from each street. This was proportionally calculated using total sample size (182) divided by revealed population (342) and then multiplied by the sampling frame for each street. The selection of personal and rental plots from each street was done based on the plot's level of compliance to setback regulations. It was also done based on the number of such plots available on a particular street (some streets have more personal than rental residential plots, while some have more rental than personal plots).

For the qualitative data, observations were also structured along the major roads and selected minor roads according to the different sectors as presented in table 3.3. Three (3) case studies with, one (1) sample from each sector was systematically selected based on level of compliance to planning approval guidelines during site development and also accessibility.

Table 3.3: Research Areas

Sector	Major Street Road	Minor Street Road
Sector 1	Community Road	Anthonia David street and Olopa Joe Ola street
Sector 2	David West Street	Obodozie street and Church Street
Sector 3	David East Street	Taiwo street, Ibikunle street and Umunnamehi Ihiala street

Table 3.4: Research Samples in Sector One

SECTOR 1	**COMMUNITY ROAD SECTOR**			
Street	**Sampling Frame (21% of 342)**	**Sample Size (21% of 182)**	**Distribution Personal**	**Rental**
Community Road (1)	15	8	4	4
Jossy Bush Street	4	2	1	1
Akin Davis Street	10	5	3	2
Anthonia David Street	10	5	3	2
Eneche Close	3	2	1	1
Phebian Onwughalu Street	4	2	1	1
Mother of Perpetual Help Street	11	6	5	1
Olopa Joe Ola Street	6	3	2	1
Josephat James Street (1)	10	5	3	2
TOTAL	**73**	**38**		

Table 3.5: Research Samples in Sector Two

SECTOR 2	DAVID WEST SECTOR			
Street	Sampling Frame (41% of 342)	Sample Size (41% of 182)	Distribution Personal	Rental
David West Street	25	13	7	6
Community Road (2)	10	5	3	2
Obodozie Street	14	8	6	2
Josephat James Street (2)	7	3	1	2
Osissa Street	5	3	2	1
Alhaji Olanrewaju Street	9	5	3	2
Ogbodu Street	15	8	6	2
Law Michael Street (1)	7	3	1	2
St. Dominic Street	9	5	2	3
Elumeke Street	13	7	5	2
Ezeorah Street	13	7	5	2
Emma Prince Street	3	2	1	1
Church Street	11	6	1	5
TOTAL	**141**	**75**		

Table 3.6: Research Samples in Sector Three

SECTOR 3	DAVID EAST SECTOR			
Street	Sampling Frame (38% of 342)	Sample Size (38% of 182)	Distribution Personal	Rental
David East Street	18	10	5	5
Community Road (3)	9	5	2	3
Alhaji Lawal Street	8	5	3	2
Holy Virgin Mary Street	12	7	3	4
Ibikunle Street	5	3	2	1
Taiwo Street	6	3	2	1
Ejuwede Street	7	4	3	1
Law Michael Street (2)	11	7	3	4
Water side Road	12	7	4	3
Ganiyu Street	8	5	3	2
Umunnamehi Ihiala Street	7	4	3	1
Olukutibi Street	7	4	2	2
Achilius Uwawulu Street	2	2	1	1
Moses Olayemi Street	6	3	2	1
TOTAL	**128**	**69**		

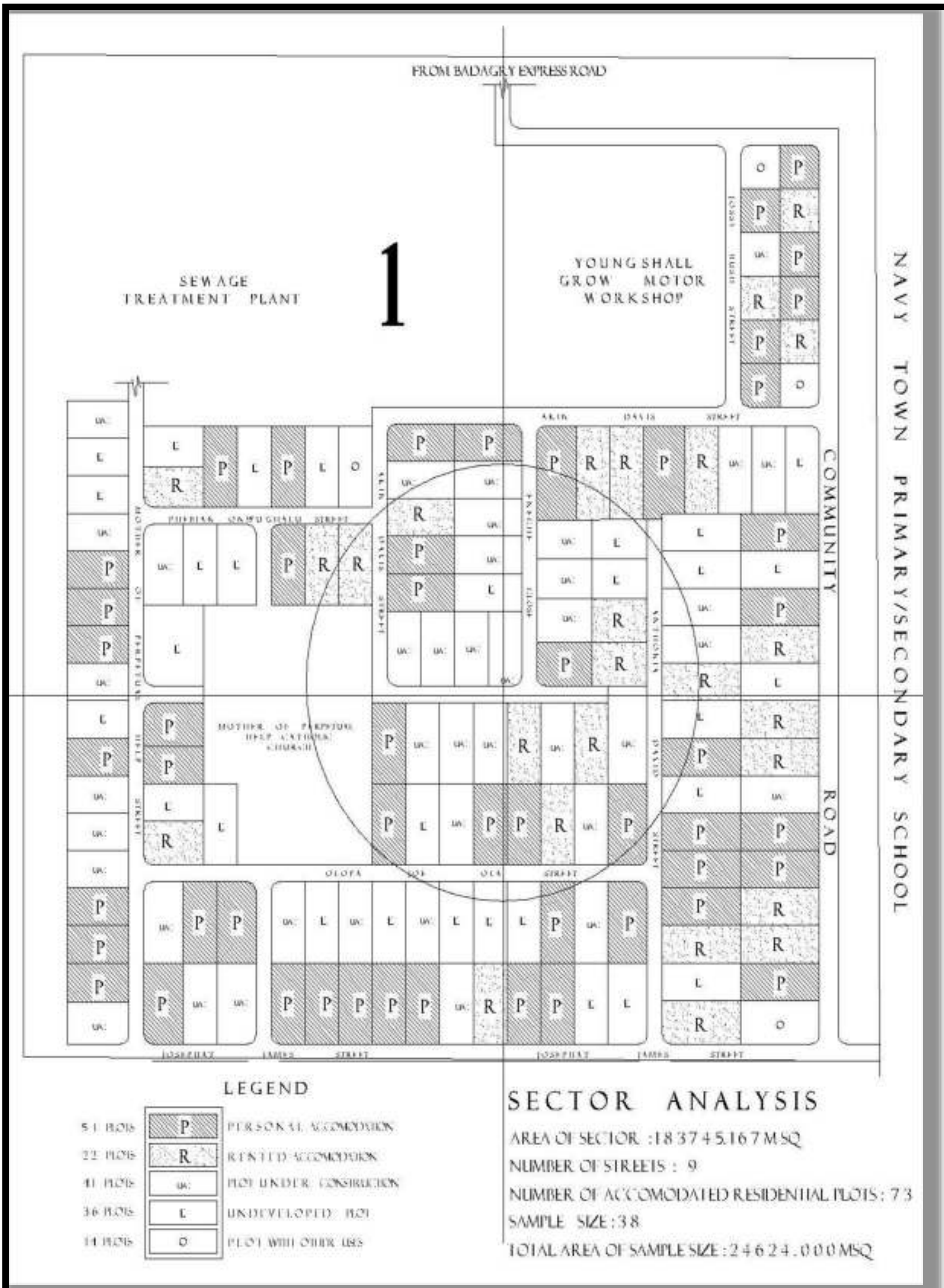

Fig 3.2: Layout Showing Sector One Sampling and research observation area of the study population

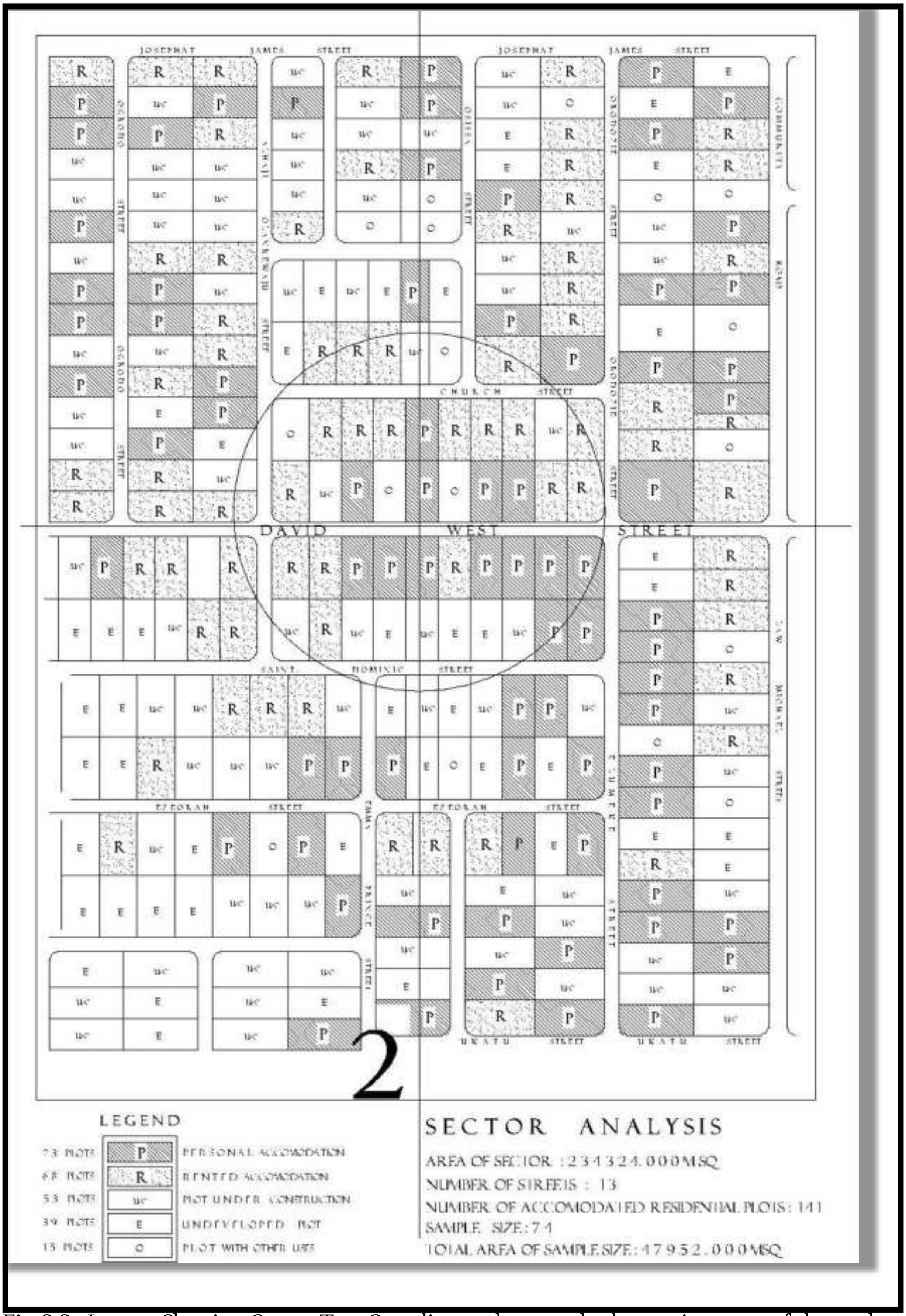

Fig 3.3: Layout Showing Sector Two Sampling and research observation area of the study population

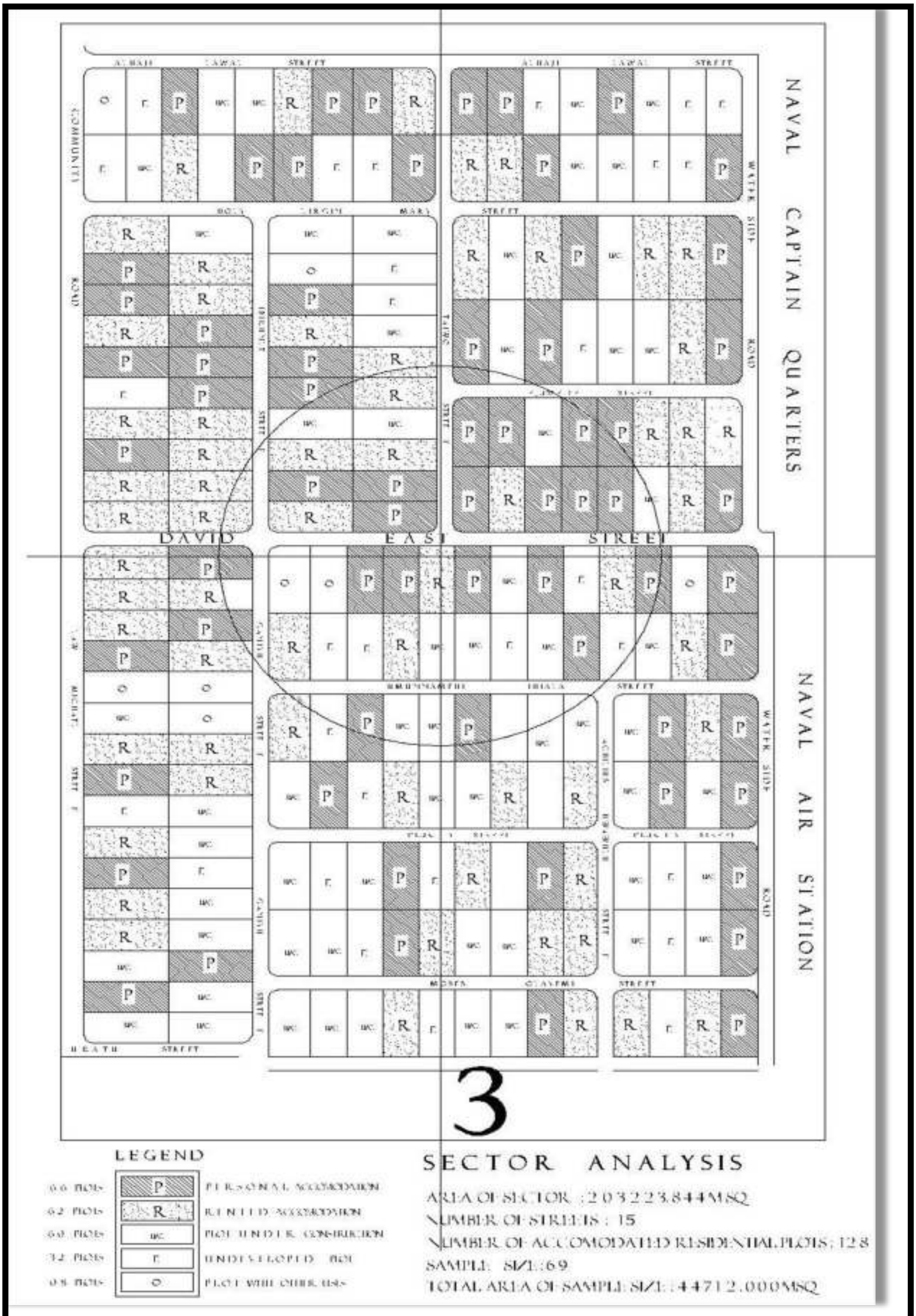

Fig 3.4: Layout Showing Sector Three Sampling and research observation area of the study population

3.6 Data Collection Instrument

A set of questionnaire was designed to elicit quantitative data from respondents. The questionnaire is divided into Four (4) subsections. The first is designed to gather information on social status of respondents, while the second and third sections are to gather information on residential site plan status and low impact development status respectively. The final section involves subjective information on effects and perceptions of non-structural low impact development infiltration strategy on residential site plan users and environment.

Qualitative data from critical observations were collected using a high pixel camera. Different panoramic shots were taken of major and minor streets in the different sectors. Also qualitative data from case studies were also collected using high quality camera, with measurements and sketches done.

3.7 Procedure for Data Collection

The questionnaire designed for this research were self-administered along with trained research assistants. One hundred and eighty-two (182) questionnaires were administered. The questionnaire was designed to retrieve data relatively to achieving the objectives of the study. A total of 182 copies of questionnaires were fully completed and retrieved for analysis.

3.8 Methods of Data Analysis

Data collected from the field were first sorted and then analysed. The method of analysis of each objective is presented in table 3.10. The table presents each objective, data location on questionnaire, data type, related hypothesis, variables in related hypothesis and method of analysis used. The analysis was done using the statistical package for social sciences (SPSS) version 21. The data analysis was done at three levels. The single factor analysis which described the population characteristics using frequency distribution tables, percentages and bar charts. The second level analysis was used to test the various hypotheses using the chi- square test of acceptance or rejection of the null hypothesis. Finally, a third level analysis was done using Tobit statistical package to carry out a multiple regression analysis to determine the effects of distance of setback space and state of setback space on thermal comfort, site aesthetics, environmental quality and landscape variety respectively. For the qualitative data, content analysis was used.

Table 3.7: Method of Analysis

Objective	Data Location	Related Hypothesis	Variable Type	Analysis Method
Examine the effects of setback distance on the level of low impact development employed within residential plots	$Q_9 – Q_{12}$, $Q_{18}– Q_{21}$	Hypothesis 1 (H_01)	Nominal & Interval	Chi- Square Test
Assess the effect of low impact development on thermal comfort within residential plots.	$Q_{18}– Q_{21}$, Q_{25}	Hypothesis 2 (H_02)	Nominal & Ordinal	Chi- Square Test Multiple Regression Analysis
Examine the implications of employing Low impact development design within residential plots on residential site aesthetics	$Q_{18}– Q_{21}$, Q_{26}	Hypothesis 3 (H_03)	Nominal & Ordinal	Chi- Square Test Multiple Regression Analysis
Evaluate the effect of low impact development on the quality of the residential environment	$Q_{18}– Q_{21}$, Q_{27}	Hypothesis 4 (H_04)	Nominal & Ordinal	Chi- Square Test Multiple Regression Analysis

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter comprises of the analyses, presentation and interpretations of the various results from the analysed qualitative and quantitative data gotten from the field.

4.1 Quantitative Data Analysis

4.1.1 Socio-economic Characteristics of Respondents

All the 182 questionnaires administered were correctly filled, returned and analysed. The analysis revealed that 55.5% were personally owned residential plots while 44.5% were rental ownership, which means that a larger percentage of the residential plots in the area were accommodated by their owners. About 81.3% of the residential plots were standard plots (18m x 36m) which indicates that there are more standard sized plots still existing after site development in the estate. The analysis further reveals that 79% of the respondents fall within the age interval of 35 – 44 and 71.4% were graduates. This is an indication that most of the accommodated residential plots in the estate were occupied by young adult graduates with first degrees and so are knowledgeable and can express themselves to a large extent. Also from the analysis, 56% of the respondents are self-employed, 22% works with corporate organisations, 17% with the civil service and 9% are retired which is an indication that virtually all the respondents are economically empowered.

4.1.2 Assessment of Residential Site Plan Status

The analysis revealed that 92.3% claimed to have site designs for their residential plot, 4.9% were uncertain and 2.7% have no site design which indicates that a large portion of the residential estate have plots with site designs. The analysis also reveals that 33% of the residential plots can accommodate 6 – 8 cars after development, 31.3% above 8 cars, 25.8% accommodating 3 – 5 cars and only 9.9% accommodating 1-2 cars. This could mean that most of the occupied residential plots in the estate give more setback space for car parking. Also from the analysis, 78.6% have open natural spaces in their residential plot, 19.8% have none and 3% were uncertain. This could mean that despite the areas developed for car parking most of the residential plots still have open natural area which could either be within the plot fence or between the plot fence and external drainage. About 83.5% of the respondents claimed to have building approval for their residential development. Also 44% of the respondents were uncertain about building control monitoring during their site development, while 26.9% had no building monitoring experience. This indicates that despite the large approval percentage it is likely that most of the residential sites in the estate were not developed in line with what was approved. Finally, in this section, 51.6% claimed to have completed their residential site development, 27.5% are not yet complete and 20.9% were uncertain. This indicates a probability that the nature of setback surfaces of almost 50% of the developed residential plots is likely to change.

4.1.3 Assessment of Low Impact Development Status

The analysis reveals that 52.2% claimed to preserve nature during site development, 44.3% did not and 0.5% were uncertain, while 61.5% introduced natural elements after site development and 38.5% did not introduce any. These results indicate that an average proportion of the developed residential plots within the estate have one form of natural surface or the other within its setbacks. Also from the analysis 53.3% used concrete for their paved areas, 44.5% laid interlocking stones with nylon underlay and 2.2% laid interlocking stones without nylon underlay. This indicates that almost all the developed residential sites within the estate have impermeable paved areas. The analysis further reveals that 32.4% had only sand as their unpaved area, 31.3% had sand and shrubs, 8.2% had sand, shrubs and trees, 8.2% have sand and grass, 6% have sand and trees while 12.1% have no unpaved area. This an indication that most of the accommodated residential plots in the estate had either sand alone or sand and some other element as their unpaved area this is most likely going to drop looking at the percentage of uncompleted accommodated sites if certain measures are now put in place.

4.1.4 Objective One, Examine the effects of building setback distance on the level of low impact development employed within residential plots

In objective one, eight variables were assessed in 182 residential plots for the significant relationship between distance left as setback space and the level of low impact development employed. The variables include the setback between the residential building and approach and side fences, residential building and rear fence and between approach fence and external drainage. It further examined the state of the space between the above mentioned building setback spaces. Descriptive summary for the 182 residential plots are presented in tables below.

From table 4.1, it can be seen that about 64.1% of the developed residential plots have approach setback distance well above 6m which is within the approved standard. It also reveals that 61% of the residential plots have their side setback distances within 3m and above which is within standard. Also 86.3% of the residential plots have their rear setback distance falling below 3m, which is below standard and 62% have setback distances above 0.5m between their approach fence and external drainage.

Table 4.2 shows that 48.4% of the approach setback space are partially paved, 47.8% are totally paved and 3.8% are unpaved which means that there is more approach paved areas within the estate. It also shows that 57.7% of the side setback spaces are paved, 20.9% are partially paved and 21.4% are unpaved, which is an indication that a larger percentage of side setback spaces within the estate are paved.62.6% of the occupied residential plot in the estate have their rear setback space paved, 13.7% partially paved and 23.6% unpaved which is also an indication that most of the rear setback spaces of developed sites within the estate are paved.

Table 4.1: Distance between Building and Site Spaces

Variable	Frequency	Valid Percent (%)
Distance between Building and Approach Fence		
1m - 2.9m	10	5.5
3m - 5.9m	55	30.2
6m - 8.9m	55	30.2
9m - Above	62	34.1
Total	**182**	**100.0**
Distance between Building and Side Fence		
0.1m - 1.9	27	14.8
2m - 2.9m	44	24.2
3m - 3.9m	78	42.9
4m - Above	33	18.1
Total	**182**	**100.0**
Distance between Building and Rear Fence		
0.1m - 1.9	91	50.0
2m - 2.9m	66	36.3
3m - 3.9m	9	4.9
4m - Above	16	8.8
Total	**182**	**100.0**
Distance between Approach Fence and Drainage		
0.0m - 0.5m	69	37.9
0.6m - 1.0m	94	51.6
1.0m - 1.5m	13	7.1
1.6m - Above	6	3.3
Total	**182**	**100.0**

Table 4.2: State of Setback Space between Building and Site Spaces

Variable	Frequency	Valid Percent (%)
State of Setback Space between Building and Approach Fence		
partially paved	88	48.4
paved	87	47.8
unpaved	7	3.8
Total	**182**	**100**
State of Setback Space between Building and Side Fence		
partially paved	38	20.9
paved	105	57.7
unpaved	39	21.4
Total	**182**	**100**
State of Setback Space between Building and Rear Fence		
partially paved	25	13.7
paved	114	62.6
unpaved	43	23.6
Total	**182**	**100**
State of Setback Space between Approach Fence and Drainage		
partially paved	34	18.7
paved	56	30.8
unpaved	92	50.5
Total	**182**	**100**

Statistical Analysis of Hypothesis One

Chi square test was employed in analysing hypothesis one, which is to check for significant relationship between low impact development and setback distance. The distributions are reported for the null hypothesis in table 4.3. The test was carried out at an alpha level of 95% confidence and 0.05 significance level.

The table 4.3 shows from the chi square test carried out that an asymptotic significant value of approximately 0.000 is arrived at for significant relationship between the distance left as approach, rear and fence setbacks and the level of low impact development within the spaces. While an asymptotic value of approximately 0.001 is arrived at for significant relationship between the distance left as side setback and the level of low impact development within the space. All the chi square values arrived at are lower than the accepted 0.05 significant level which indicates that there is significant relationship between the distance left as setback space around a residential building and the level of low impact development strategy employed around the residential building, hence the null hypotheses are rejected.

Table 4.3: Chi square test between the different Setback Distances in the residential plot and State of setback space

CHI-SQUARE TESTS

Setback Distance	VALUES		df	Asymptotic Value
	Likelihood Ratio	Pearson Chi-Square		
Approach Setback	36.148[a]	40.041	6	**.000**
Side Setback	21.799	20.182	6	**.001**
Rear Setback	97.012	67.953	6	**.000**
Approach Fence/Drainage	44.494	58.957	6	**.000**
N of Valid Cases	182			

4.1.5 Objective Two, Assess the effect of low impact development on thermal comfort within residential plots.

In objective two, five variables were assessed in 182 residential plots for significant relationship between state of setback space and the thermal comfort. The variables include the state of the space between the residential building and approach, sides and rear fences and also approach fence and external drainage and thermal comfort perception of respondent. Descriptive summary for the evaluation of respondent's thermal comfort of the 182 residential plots assessed is presented in chart 4.1. The chart shows that 58 of the respondents have an average perception to thermal comfort within their residential plot, 17 have a high thermal comfort perception and 107 have a low thermal comfort perception.

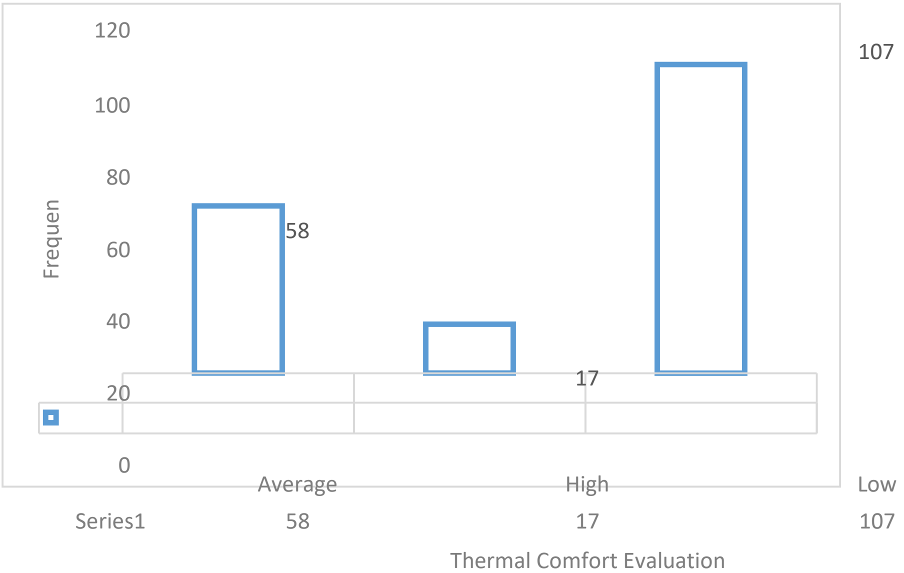

Chart 4.1: Site Setback Thermal Comfort Evaluation

Statistical Analysis of Hypothesis Two

Chi square test was employed in analysing hypothesis two, which is to check for significant relationship between thermal comfort and the state of setback. The distributions are reported below for the null hypothesis in table 4.4. The test was carried out at an alpha level of 95% confidence and 0.05 significance level.

The table 4.4 shows from the chi square test carried out that an asymptotic significant value of approximately 0.000 is arrived at for significant relationship between the states of approach, side and rear setbacks and the level of thermal comfort within the spaces. While an asymptotic value of approximately 0.005 is arrived at for significant relationship between fence setback state and the thermal comfort within the space. All the chi square values arrived at are lower than the accepted 0.05 significant level which indicates that there is significant relationship between the state of setback space around a residential building and the level of thermal comfort around the residential building, hence the null hypotheses are rejected.

Table 4.4: Chi square test between the different setback states around the residential building and the level of thermal comfort around the residential building.

CHI-SQUARE TESTS				
Setback State	VALUES Likelihood Ratio	Pearson Chi-Square	df	Asymptotic Value
Approach Setback	23.284	20.563	6	**.000**
Side Setback	46.004	46.302	6	**.000**
Rear Setback	32.220	30.880	6	**.000**
Approach Fence/Drainage	14.919	14.224	6	**.005**
N of Valid Cases	182			

4.1.6 Objective Three, Identify the effects of employing Low impact development design within residential plots on residential site aesthetics.

In objective three, five variables were assessed in 182 residential plots for significant relationship between the state of setback space and the site aesthetics/ beauty within setbacks. The variables include the state of the space between the residential building and approach, side and rear fences, approach fence and external drainage and site aesthetics evaluation of respondent. Descriptive summary for the 182 residential plots are presented chart 4.2. The chart shows that 93 of the respondents have an average perception to plot aesthetics within their residential plot, 13 have a high site aesthetic perception and 76 have a low aesthetic perception of their residential plots.

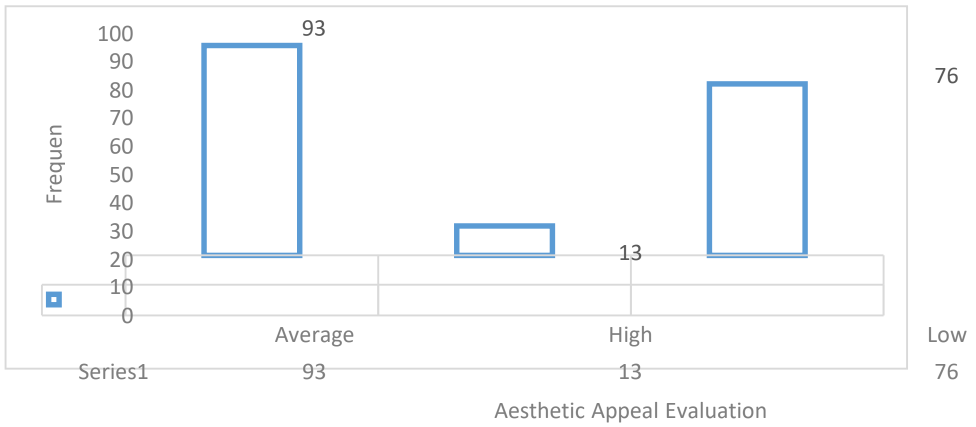

Chart 4.2: Site Setback Aesthetics Evaluation

Statistical Analysis of Hypothesis Three

Chi square test was employed in analysing hypothesis three, which is to check for significant relationship between site aesthetics and the state of the state of the setback space. The distributions are reported below for the null hypothesis in table 4.5. The test was carried out at an alpha level of 95% confidence and 0.05 significance level.

The table 4.5 shows from the chi square test carried out that asymptotic significant values of approximately 0.000 and 0.039 were arrived at for significant relationship between the state of approach and fence setback and the level of plot aesthetics within the spaces respectively. These chi square values arrived at are lower than the accepted 0.05 significant level which indicates that there is significant relationship between the state of approach and fence setback spaces of a residential building and the level of plot aesthetics around the residential building, hence the null hypotheses are rejected. While asymptotic values of approximately 0.342 and 0.172 were arrived at for significant relationship between side and rear setback states and the plot aesthetics within the spaces respectively. These chi square values arrived at are higher than the accepted 0.05 significant level which indicates that there is no significant relationship between the state of side and rear setback spaces of the residential building and the level of plot aesthetics around the residential building, hence the null hypotheses are accepted.

Table 4.5: Chi square test between the different setback states around the residential building and the level of plot aesthetics around the residential building.

CHI-SQUARE TESTS

Setback State	VALUES **Likelihood Ratio**	 **Pearson Chi-Square**	**df**	**Asymptotic Value**
Approach Setback	21.811	22.890	6	**.000**
Side Setback	4.506	4.570	6	**.342**
Rear Setback	6.395	6.426	6	**.172**
Approach Fence/Drainage	10.070	14.030	6	**.039**
N of Valid Cases	182			

4.1.7 Objective Four (Evaluate the effect of low impact development on the residential environmental quality)

In objective four, five variables were assessed in 182 residential plots for significant relationship state of setback space and the environmental quality within setbacks. The variables include the state of the space between the residential building and approach fence, side, and rear fences and also approach fence and external drainage and site's environmental quality evaluation of respondent. Descriptive summary for the 182 residential plots are presented in chart 4.3. The chart shows that 101 of the respondents have an average environmental quality perception within their residential plot, 13 have a high environmental quality perception and 68 have a low environmental quality perception of their residential site.

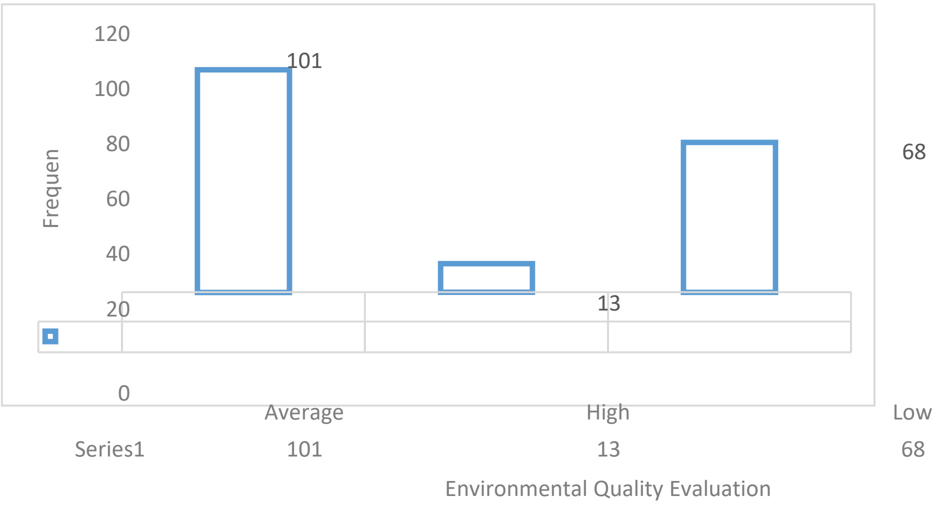

Chart 4.3: Site Setback Environmental Quality Evaluation

Statistical Analysis of Hypothesis Four

Chi square test was employed in analysing hypothesis four, which is to check for significant relationship between environmental quality and state of setback space. The distributions are reported below for the null hypothesis in table 4.6. The test was carried out at an alpha level of 95% confidence and 0.05 significance level.

The table 4.6 shows from the chi square test carried out that an asymptotic significant value of approximately 0.000 is arrived at for significant relationship between the states of approach, side, rear and fence setbacks and the level of environmental quality within the spaces. This chi square value arrived at is lower than the accepted 0.05 significant level which indicates that there is significant relationship between the state of setback space around a residential building and the level of environmental comfort around the residential building, hence the null hypotheses are rejected.

Table 4.6: Chi square test between the different setback states around the residential building and the level of environmental quality around the residential building.

CHI-SQUARE TESTS

Setback State	VALUES		df	Asymptotic Value
	Likelihood Ratio	Pearson Chi-Square		
Approach Setback	25.395	26.584	6	**.000**
Side Setback	68.069	67.729	6	**.000**
Rear Setback	42.261	42.950	6	**.000**
Approach Fence/Drainage	24.273	21.307	6	**.000**
N of Valid Cases	182			

4.1.8 Regression analysis to determine the effects of distance of setback space and state of setback space on thermal comfort

Multiple regression analysis was employed to assess the effects of setback distance and state on residential site's thermal comfort. The analysis revealed that distance of front, fence and side setbacks have positive coefficients while rear setback distance, state of front setback, fence setback, side setback and rear setback have negative coefficients as presented in table 4.7. This indicates that increase in setback distances and decrease in paving will improve thermal comfort on residential plots.

Table 4.7: Effects of Site setback and setback state on site's thermal comfort

Dependent Variable: SITE_S_THERMAL_COMFORT

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.049223	0.855509	2.395324	0.0166
FRONT_SETBACK	0.545011	0.147567	3.693308	0.0002
FENCE_SETBACK	0.677890	0.188717	3.592104	0.0003
SIDE_SETBACK	0.331870	0.143173	2.317967	0.0205
REAR_SETBACK	-0.226064	0.149000	-1.517212	0.1292
FENCE_SETBK_STATE	-0.304440	0.179127	-1.699576	0.0892
FRONT_SETBK_STATE	-0.724190	0.228584	-3.168159	0.0015
SIDE_SETBK_STATE	-0.524668	0.201837	-2.599461	0.0093
REAR_SETBK_STATE	-0.459493	0.179748	-2.556312	0.0106
Uncensored obs	58	**Total Obs**		182

4.1.9 Regression analysis to determine the effects of distance of setback space and state of setback space on site aesthetics

Multiple regression analysis employed to assess the effects of setback distance and state on residential site aesthetics. The analysis revealed that distance of front setback, fence setback side setback, rear setback and side setback state have positive coefficients while state of front setback, fence setback and rear setback have negative coefficients as presented in table 4.8. This indicates that increase in setback distances and side setback paving and decrease in paving will improve aesthetics on residential plots.

Table 4.8: Effects of Site setback and setback state on site's aesthetics

Dependent Variable: SITE_S_AESTHETICS

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.420592	0.646013	2.199013	0.0279
FRONT_SETBACK	0.336619	0.098990	3.400521	0.0007
FENCE_SETBACK	0.230427	0.118230	1.948975	0.0513
SIDE_SETBACK	0.065629	0.092515	0.709393	0.4781
REAR_SETBACK	0.083339	0.092840	0.897664	0.3694
FENCE_SETBK_STATE	-0.266196	0.112170	-2.373147	0.0176
FRONT_SETBK_STATE	-0.479400	0.150269	-3.190289	0.0014
SIDE_SETBK_STATE	0.198257	0.142424	1.392016	0.1639
REAR_SETBK_STATE	-0.244948	0.128037	-1.913108	0.0557
Uncensored obs	93	**Total obs**		182

4.1.10 Regression analysis to determine the effects of distance of setback space and state of setback space on environmental quality

Multiple regression analysis was employed to assess the effects of setback distance and state on residential site's environmental quality. The analysis revealed that distance of front setback, fence setback side setback and rear setback have positive coefficients while rear setback distance, state of front setback, state of fence setback and state rear setback have negative coefficients as presented in table 4.9. This indicates that increase in setback distances, decrease in rear setback distance and decrease in paving will improve environmental quality on residential plots.

Table 4.9: Effects of Site setback and setback state on site's environmental quality

Dependent Variable: SITE_S_ENVIRONMENTAL

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.843041	0.497521	5.714419	0.0000
FRONT_SETBACK	0.236013	0.075604	3.121703	0.0018
FENCE_SETBACK	0.103326	0.095933	1.077065	0.2815
SIDE_SETBACK	0.086972	0.074228	1.171687	0.2413
REAR_SETBACK	-0.045913	0.075321	-0.609560	0.5422
FENCE_SETBK_STATE	-0.110429	0.087877	-1.256640	0.2089
FRONT_SETBK_STATE	-0.302431	0.120862	-2.502276	0.0123
SIDE_SETBK_STATE	-0.391699	0.109670	-3.571626	0.0004
REAR_SETBK_STATE	-0.212290	0.098392	-2.157582	0.0310
Uncensored obs	101	**Total obs**		182

4.2 Qualitative Data Analysis

Qualitative data analysis was carried out through analysing data collected from structured observations with the aim of assessing external site setback situations of residential plots along major roads and selected minor street roads within the residential estate. Case studies of some selected plots were also done to assess site set back situations as it relates to level of employment of low impact development. Three (3) case studies were carried out with one (1) systematically selected from each sector based on the level of compliance with planning approval guidelines during site development and also accessibility.

4.2.1 Observations from Major Streets

Spaces between fences and external drainages for most residential plots along Major roads were observed to be covered with concrete and converted into entrance terraces for shops and other commercial uses. It was also observed that most approach fences along major roads were converted into shops, thereby reducing approach drainage and approach setback distance. Though this shops provided shades, improving thermal comfort with negative impacts on site aesthetics, environmental quality (plates 4.1, 4.2 and 4.3).

Plate 4.1: Panoramic view of Community road in sector 1, showing the commercial and paved nature of the setback spaces between the approach fence and external drainage

Plate 4.2: Panoramic view of David West Street in sector Two

Plate 4.3: Panoramic view of David East Street in sector Three

4.2.2 Observations from Minor Street

Spaces between fences and external drainages for most residential plots along Minor roads were observed to be partially covered with concrete/ interlock stones mixed with shrubs while some are totally unpaved accommodating sand, grasses and shrubs and with approach fences still being retained. Though this created open unshaded spaces, it had positive impacts on site aesthetics, environmental quality (plates 4.4, 4.5 and 4.6).

Plate 4.4: Panoramic view of Anthonia David Street in sector one, showing the natural and unpaved nature of the setback space between the approach fence and external drainage

Plate 4.5: Panoramic view of Church Street in sector two

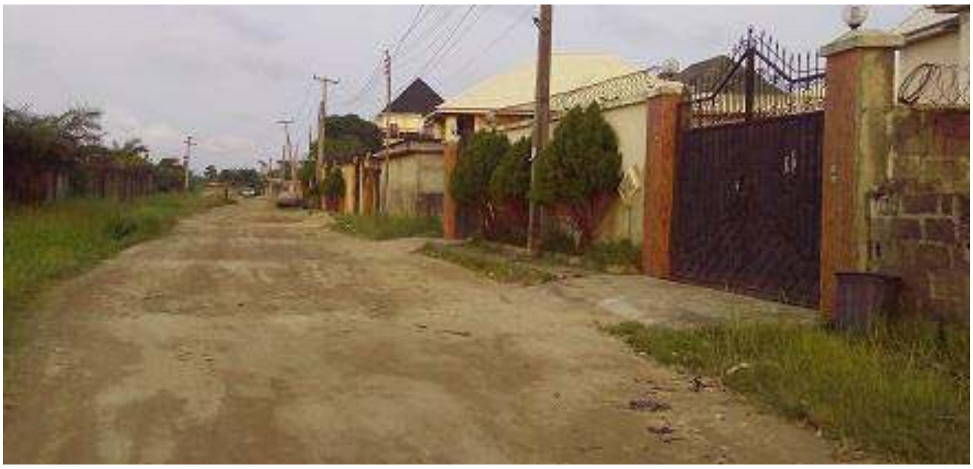

Plate 4.6: Panoramic view of Alhaji Lawal Street in sector three

Plate 4.7: Panoramic view of Olopa Joe Ola Street in sector one

Plate 4.8: Panoramic view of Ibikunle Street in sector three

4.2.3 Case Studies

i. Case Study One

Case study one is an owner occupied residential plot situated along Obodozie Street in New-site residential estate, satellite town, Lagos. The residential building is accommodated and was fully completed in November, 2014. The plot size is 648m^2 which is generally referred to as standard plot of land in the estate. The residential plot has a setback of 23.2m^2 between the residential building in the plot and its approach fence with a distance of 3.9m from the approach fence inwards used as office space. The residential plot is also characterized by setback distances of 1.2m, 1.5m and 3m from the residential building in the plot to its sides and rear fences respectively as presented in figure 4.1.

The setback space between the approach fence and residential building on the plot is mainly paved with interlocking stones laid on well compacted sharp sand, with a damp proof membrane layer between the interlocking stones and sharp sand layers as presented in plate 4.10. The setback spaces on the residential building sides are unpaved except for areas occupied by septic tank concrete slabs. The setback space at the rear of the building is paved with monolithic concrete as presented in plate 4.12.

The residential plot has an undeveloped total area of 457.454m^2 with 289.400m^2 paved with impermeable materials and 168.054 left unpaved, accommodating and enhancing various natural occurrences and elements such as sand, vegetables, shrubs and trees as presented in figure 4.1 and plate 4.10.

Despite the large area covered by impermeable materials, a wide area of about 60% is shaded from the sun's ultra-violet rays by trees preserved and incorporated into impermeable paving areas during site development, subsequently reducing heat island areas in the residential plot despite the large solar heat enhancing surface. With the remaining 40% of the unpaved area being left exposed to solar heating and other associated environmental and human issues, such as soil compaction, thermal discomfort and depletion of natural elements, there is a need to increase the site's unpaved (natural infiltration) area. Achieving permeable natural surfaces such as sharp sand pools, grass lawns and various natural ground covers will create more area to enhance the residential site's landscape variety, colour and texture, hence improving environmental quality and human wellbeing in the residential plot.

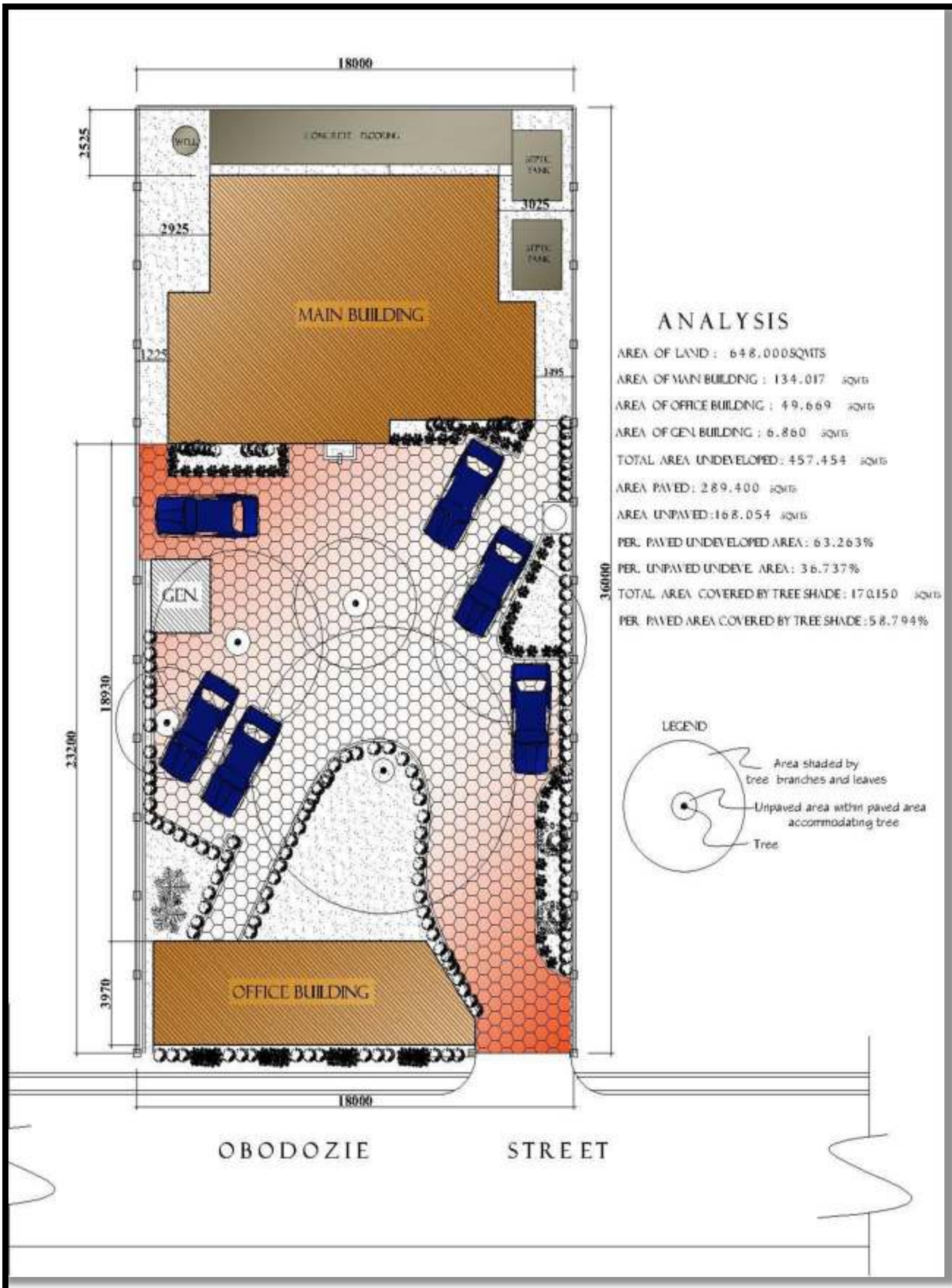

Fig 4.1: Site plan of case study one,

Plate 4.9: External approach of Case study one, showing the nature of the setback space between the approach fence and external drainage

Plate 4.10: Showing trees incorporated into paved areas, covering a wide area of the setback space between approach fence and residential building

Plate 4.11: sharp sand on side set back space

Plate 4.12: Concrete flooring covering rear Set back space

ii Case Study Two

Case study two is an owner occupier residential plot situated along Ezeorah Street in New-site residential estate, satellite town, Lagos. The residential plot is accommodated and was fully completed in July, 2016. The plot size is $348m^2$ which is generally referred to as half of a standard plot of land in the estate. The residential plot has a setback distance of $5.4m^2$ between the residential building in the plot and its approach fence. The residential plot is also characterized by setback distances of 2.7 m and 1.5m between the residential building in the plot and its side fence and rear respectively as presented in figure 4.2.

The setback between the approach fence and residential building on the plot is mainly paved with interlocking stones laid on well compacted sharp sand, with a damp proof membrane layer between the interlock stone and sharp land layers. The setback spaces on the residential building sides and rear are also paved with interlocking stone paving as shown in plates 4.16 and 4.17.

The residential plot has an undeveloped total area of $168.497m^2$ of which $155.503m^2$ is paved with impermeable paving materials and $12.994m^2$ left unpaved, accommodating various natural elements such as sand, shrubs and flowers. The large paved area is exposed to solar heating and other associated environmental and human issues, such as soil compaction, thermal discomfort and depletion of natural elements, hence, the need to increase the site's unpaved (natural infiltration) area. Achieving permeable natural surfaces such as sharp sand pools, grass lawns and various natural ground covers, trees and shrubs will create more area to enhance the residential site's landscape variety, colour and texture, hence improving environmental quality and human wellbeing in the residential plot.

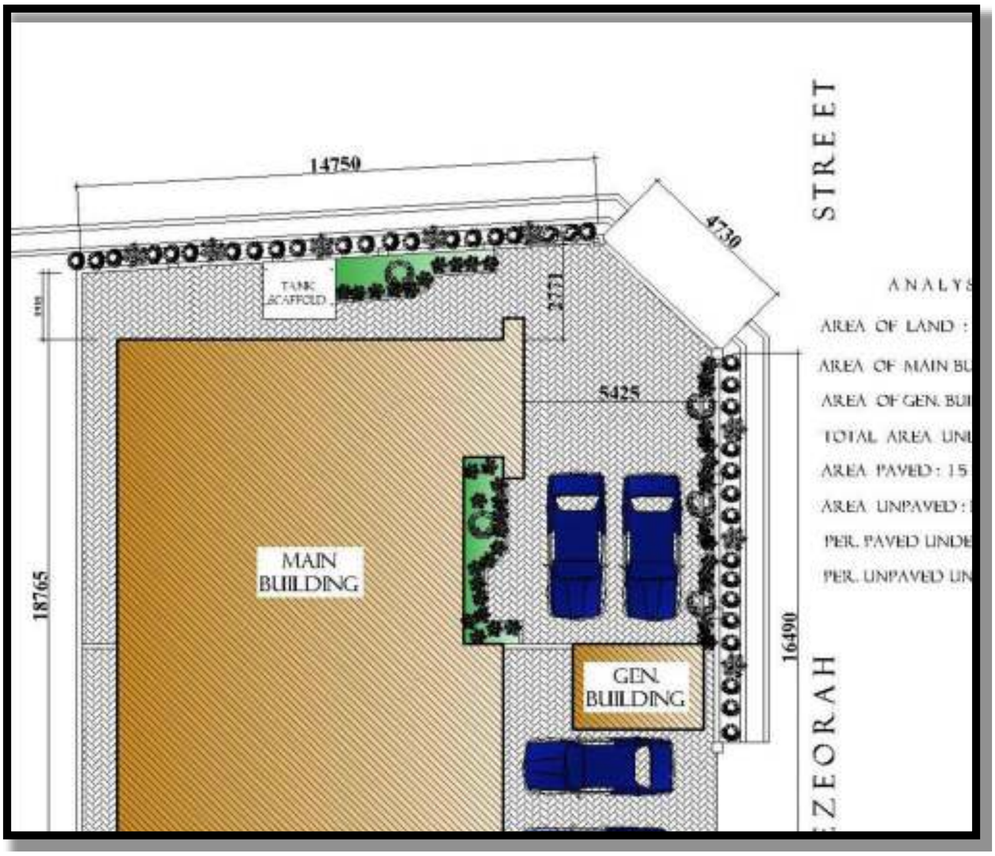

Fig 4.2: Site plan of case study two

Plate 4.13: External approach of case study 2, showing the state of the setback space between the approach fence and external drainage

Plate 4.14: State of the setback space between the approach fence and residential building

Plate 4.15: State of the unpaved area within setback space between the approach fence and residential building

Plate 4.16: sharp sand on side set back space

Plate 4.17: Concrete flooring covering rear Set back space

iii Case Study Three

Case study three is a tenant occupied residential plot situated along David Street in New-site residential estate, satellite town, Lagos. The residential building is accommodated and was fully completed in April, 2010. The residential plot size is $648m^2$ which is generally referred to as a standard plot of land in the estate. It has a setback distance of $5.5m^2$ between the residential building in the plot and its approach fence with a distance of 3.0m from the approach fence inwards used as block of shops. The plot is also characterized by setback distances of 1.5m and 5m respectively between the residential building in the plot and its side fences, as well as a setback distance of 6.9 m at its rear end accommodating a minor building as presented in figure 4.3.

The setback between the approach fence and residential building in the plot was totally paved with interlocking tiles laid on well compacted sharp sand, with a damp proof membrane layer between the interlock tiles and sharp sand layers. The setback spaces in the residential building sides and rear end also were paved with interlocking tile paving as shown in plate 4.19 and plate 4.20.

The residential plot has an undeveloped total area of $290.329m^2$ which was totally paved with impermeable interlocking tile and no area was left unpaved to accommodate natural elements such as sand, grasses, shrubs, and trees. The large paved area is exposed to solar heating and other associated environmental and human challenges, such as soil compaction, thermal discomfort and depletion of natural elements, hence, the need to provide unpaved (natural infiltration) area in the site. Achieving permeable natural surfaces such as sharp sand pools, grass lawns and various natural ground covers, trees and shrubs will enhance the residential site’s landscape variety, colour and texture, hence improve environmental quality and human wellbeing in the residential plot.

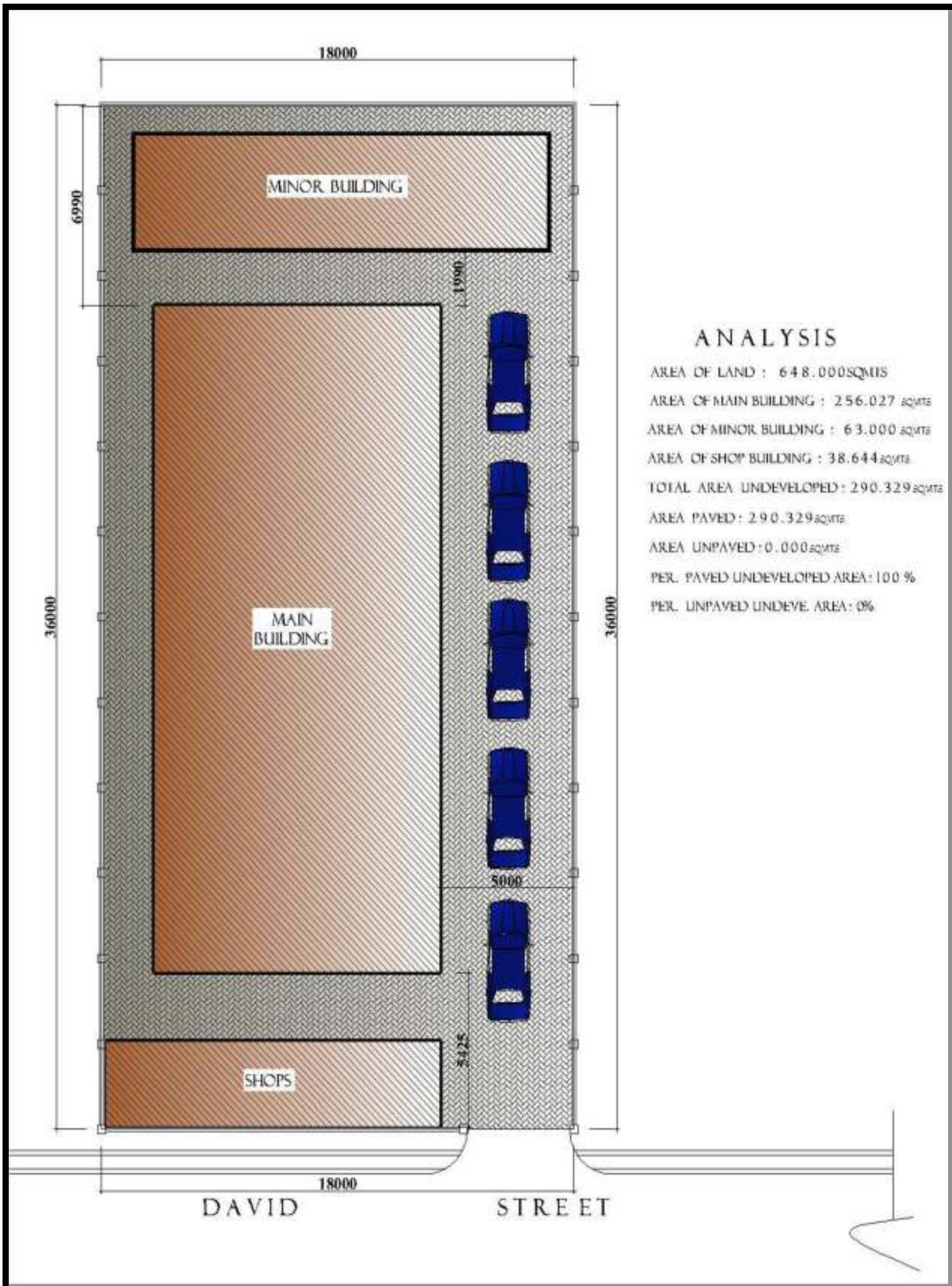

Fig 4.3: Site plan of case study three

Plate 4.18: External approach of case study 3, showing the nature of the setback space between the approach fence and external drainage

Plate 4.19: State of the setback space between the side fence and residential building

Plate 4.20: State of the setback space between the approach fence and residential building

CHAPTER FIVE

5.0 SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.1 Summary

The study reveals that Low impact development infiltration strategies can be achieved in residential sites in Lagos, Nigeria basically through enhancing soil infiltration in open spaces within setbacks of residential sites. It further reveals that setback regulations have been greatly contravened by residential plot owners while developing their building structures, which has consequently affected the level of low impact development strategies employed within setbacks. Despite these contraventions the results from the study on the various effects of low impact development strategies on residential plots are summarized in the tables 5.1 and 5.2. Generally, from the tables an increase in the setback distance around the residential building and a decrease in the level of impermeable paving within setbacks will improve the thermal comfort, site aesthetics and environmental quality of the residential plot.

Table 5.1: Summary of findings from Quantitative data

Objective	Related Hypothesis	Findings from Chi square test	Findings from Multiple Regression Analysis
Examine the effects of setback distance on the level of LID employed within residential plots	Hypothesis 1 ($H_0$1)	Significant relationship exists between setback distances on all sides of the residential plot and level of Low impact development employed.	It was discovered that an increase in the distance left as setback on any side of the residential plot will improve the level of low impact development
Assess the effect of LID on thermal comfort within residential plots	Hypothesis 2 ($H_0$2)	Significant relationship exists between setback state on all sides of the residential plot and thermal comfort of plot	Increase in setback distance and decrease in paving within residential plot setbacks improves thermal comfort
Examine the implications of employing LID design within setbacks on site aesthetics	Hypothesis 3 ($H_0$3)	Significant relationship exists between approach and fence setback state of the residential plot and site aesthetics and none between side and rear setback state and site aesthetics	Increase in setback distance, increase in side setback paving and decrease in paving of other setback areas within setbacks will improve site aesthetics
Evaluate the effect of LID on the quality residential environmental	Hypothesis 4 ($H_0$4)	Significant relationship exists between setback state on all sides of the residential plot and environmental quality within setbacks	Increase in setback distance and decrease in paving within setbacks will improve environmental quality

Table 5.2: Summary of findings from Qualitative data

Objective	Findings from Field Observations and case study
Examine the effects of setback distance on the level of low impact development employed within residential plots	For external plot situations along major roads, setback distance did not create opportunity for the use of LID due to commercial activities. For external plot situations along minor roads, setback distance created minor opportunity for LID as employed within different setback distances. From case studies it was discovered that irrespective of the distance left for setback, some level of low impact development such as sand cover, grass cover and shrubs were employed, but the LID level increased with increase in the setback distance. Also some factors such as hardscape areas for packing and resident's preferences affected the level of LID within the residential plots.
Assess the effect of low impact development on thermal comfort within residential plots.	For external plot situations along major roads, the lack of employment of LID had little effects on thermal comfort, because this was achieved by different canopy coverings and structures. From case studies, a strong positive relationship was seen between LID of a small space and thermal comfort of a large paved area within the same setback space. This was made possible by a tree incorporated into a small area with the shades provided by the branches of the tree created thermal comfort over the large paved area it covered.
Examine the implications of employing Low impact development design within residential plots on residential site aesthetics	From observations and case studies, it was observed that the level of non-structural low impact development infiltration approach employed had relatively strong effects on residential site's aesthetics through the different forms, colours and shades provided by the LID independent management practices employed within the setbacks.
Evaluate the effect of low impact development on the quality residential environmental	From observations and case studies, it was discovered that the level of non-structural low impact development infiltration approach employed had strong effects on residential site environmental quality through enhancement of soil water recharge and biodiversity especially plant development observed within infiltration areas of the residential plot.

5.2 Recommendations

The following are the recommendations evolving from the results of the study

1. The Federal, state and local agencies in charge of building developments should revive their monitoring team to ensure the compliance and adherence to setback standards during site development.

2. Government's building control and monitoring agencies should go beyond checking for the compliance with building setback standards alone, but should include compliance with introduction of low impact development practices on site.
3. The government through its various housing authorities should periodically organise low impact and sustainable development programmes to constantly enlighten building users, developers and professionals about the strategies and essence to develop sustainably.
4. An area of the residential plot must be set aside for low impact development to serve as environmental sustaining and aesthetic enhancing area of residential plots during plot development, which must be adhered to and presented as part of the analysis on the site plan drawing before approval.
5. Residential plot owners must ensure that at least a tree is planted within their residential plot to enhance human comfort, reduce the effects of heat islands from inevitable paved areas and generally improve environmental quality.

5.3 Conclusion

The study through its research methodology and analysis has presented results to show that the thermal comfort, environmental aesthetics and quality of residential sites are largely dependent on the availability of setback distance and the state of setback ground. It further reveals from its multivariate analysis that the more the provision of spaces for setback and lesser the areas paved, the higher the quality of the residential site.

The study also reveals that the distance left as setback is a major determinant of the level of low impact development practice employable within the residential development. Though the study has proven that the minimum standard regulation for setbacks as authorized by the Federal Housing Authority of Nigeria is reasonably adequate, more compliance with this standard by residential site owners was observed to be the underlying factor hindering the actualization of low impact development in the area.

The study therefore concludes that through Government's implementation of the preservation of a certain area for low impact development strategies during residential site approval and monitoring, there is a large likelihood of achieving environmental sustenance and human wellbeing within residential plots. Complimenting this implementation with public sustainable development enlightenment programmes will enhance low impact development of residential plots in Lagos and Nigeria at large.

5.4 Contribution to Knowledge

This research has provided information on the effects of low impact development practices on residential plot development schemes. It has also proffered policy recommendations for all stakeholders in the building industry on site features that could promote thermal comfort, environmental aesthetics and quality within the residential plots.

5.5 Areas of Further Research

a. The study of non-structural low impact development of residential sites and its effect on the residential building structure will ensure better residential designs in Lagos state and other states of Nigeria.

b. The study of the acceptable percentage utilization of sites for efficient and comfortable sustainable environmental development.

REFERENCES

Ademola, A. (2001).Strategies for Sustainable Land use Planning and Management in Nigeria, 21st Century Joint Workshop / Meeting of Lands officers held in Abuja, 5th & 6th December, 2001.

Ahiablame, L.M , Engel, B.A & Chaubey, I (2012). Effectiveness of Low Impact Development Practices: Literature Review and Suggestions for Future Research, retrieved from http//www.springerscience, July 2016.

Anastas, P.T & Zimmerman,J.B (2003).Design through Twelve Principles of Green Engineering, Journal of Environmental Science and Technology, 2003, 37, 94A-101A

Anne, G. (2008) Achieving Sustainable Site through Low Impact Development Practices, Retrieved from http://www. National Institute of Building Sciences.org February 2016.

Anne, G. (2016) Low Impact Development Technologies, Retrieved from http://www.wbdg.org, September, 2016

Anomie B.O.T (Ed) (2014) Site Planning retrieved 2014 from http//en.m.wikipedia.org/wiki/site-planning.

ATA Engineering (2016). Conceptual Design, retrieved from http//www.ata-e.com/services/conceptual, July 2016.

Ayeni, D.A & Olalusi, C.A (2011) Sustained Beautification of Nigerian Cities through Landscaping; the case study of Akure , In Laryeas, Agyepong, S.A, Leiringer, R. and Itughes, W (eds) Proceedings of the 4th West Africa Built Environment Research (WABER) Conference 24th-26th July, Abuja, pp 345-354.

Benjamin, C. (2000). Ne*wton's* Third Law, retrieved from http://www.lightandmatter.com, August 2016.

Benzu, J.K (2010) Natural landscape vs Artificial Environment,retrieved from http//www.wikipedia/wiki/Natural landscape, September 2016.

Bob, C (2011) The Green Civil Engineer, Sustainable Site Planning Basics, retrieved from http://www.greencivilengineer.com/2011/05/sustainable-site-planning-basics.html, February 2016.

Buro, H. (2016). Master Planning, retrieved from http//www.designingbuildings.co.uk, July 2016.

Cabayi, (Ed)(2016) Low Impact Development (US and Canada), retrieved from http://en.m.wikipedia.org/wiki/low-impact, October 2016.

Coffman, L.S(2001). Low Impact Development: Creating a storm of controversy. Water Resources Impact, 3(6), 7-9 retrieved from http://www.gwra.org.

Coffman, L.S(2002). Low Impact Development: An Alternative Storm Water Technology, In handbook of water sensitive planning and design, France, R.L (ed), Lewis Publishers, Boca Raton.

Contech Engineered Solutions (2012) What is LID? Five Principles of Low Impact Development , retrieved from http://www.conteches.com/stormwater-blog, August 2016.

Creative Research Systems (2012). Sample Size Calculator, retrieved from http://www.surveysystem.com/sscalc.html, August 2016.

David, T (2016) Top Five Strategies to A Sustainable Site, retrieved from http//www.wncgreenblog collective.wordpress.com, July 2016.

Davis, A.P (2005). Green Engineering, Journal of Environmental Science and Technology, August 15, 2005, 39, pp 339A-345A.

Davis, A.P, Hunt, W.F, Traver, R.G & Clar, M. (2009). Bio retention Technology: overview of Current Practice and Future Needs, Journal of Environmental Engineering, 135, pp109-117.

Dietz, M.E (2007). Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions, Springer Science +Business Media, Utah.

Fadamiro, J.A (2010) Landscape Architecture: Dynamics of City Development, Inaugural Lecture series 58; delivered at the Federal University of Technology Akure, Ondo State, Nigeria.

Fairle, S. (1996) Low Impact Development: Planning and people in a sustainable countryside, John Carpenter P.,Charlbury.

Fairle, S. (2009) Low Impact Development: The future in our hands, retrieved from http://www.creative commons.org/lincenses/by-nc-sc, October, 2016.

Federal Ministry of Works and Housing, URD Division (2001), Development Control Guideline on Federal Government lands, foreshore, highways setbacks and estates in Nigeria,Workshop held at Mabushi, Abuja, 2001.

Garry, B. (2000).Construction Documentation Specification, John Wiley and Sons Inc.,

Good, O. (Ed) (2016) Low Impact Development, Retrieved from http://www.wikipedia.org/wiki/Low-impact-development, July 2016

Guilette, T. (2010) Low Impact Development Technologies, online publication retrieved from

https://www.wbdg.org., September 2016

Hogan, C.M (2010) Abiotic Factor, retrieved from https://www.eoearthlive. wordpress.com/ article/abiotic-factor, September 2016

Holman-Dodds, J.K, Allen, B. & Kenneth W.P (2004). Evaluation of Hydrologic Benefits of Infiltration, Based Urban Storm water Management, Journal of American Water Resources Association, 39 (1) pp 205-215.

Hunt, W.F, Traver, R.G, Davis, A.P, Emerson, C.H, Collins, K.A & Stagge, J.H (2010). Low Impact Development Practices: Designing to infiltrate in Urban Environments, in Chang, N. (Ed).Effects of Urbanization on Ground Water (pp 308-343), Environment Water Resource Institute, Reston.

John, G.(2009). Guidelines for Planning Authorities on sustainable Residential Development in Urban Areas, Stationary Office, Dublin.

Kerry, B (2007) The Benefits of Sustainable Site Planning, retrieved from http://www.healthcaredesignmagazine.com/article/benefits-sustainable-site-planning, February 2016.

Kothari, C.I (2004) "Research Methodology, Methods and Techniques". Second revised edition, New Age International (p) Limited, New Delhi.

Krejcie, R.V & Morgan, D.W (1970) Determining Sample for Research Activities, Educational and Psychological Measurement, 30, 607-610.

Low Impact Development Centre (2007) Introduction to Low Impact Development, retrieved from http://www.Lid-stormwater.ed/background.htm, October 2016

Lynch, K. & Gary Hack (1996). Site Planning, MIT Press, Cambridge.

Lynn, R., Kahle, E. & Gurel, A (Eds) (2014) Communicating Sustainability for the Green Economy , M.Sharpe, Newyork.

Maxey, L. (2013) The future in our hands: Low Impact Development and Sustainability Transition, retrieved from http://www.acedemia.edu, October 2016.

Michael, E.D (2007) Low Impact Development Practices, Springer Science + Business Media, Utah.

Motloch, J.L (1991). Introduction to Landscape Design, Van Nostrand Reinhold Publishers, Carlifornia.

Muhammad, S.U (2015). Introduction to Site Planning, retrieved from http//www.kuet.ac.bd/webportal/ppmv2/uploads., August, 2016.

National Geographic Society (2017) Landscape , retrieved from http://www.geography.org September, 2017.

New Jersey Department of Environmental Protection (2004) Low Impact Development Techniques, New Jersey storm water Best Management Practices Manual, retrieved from http://www.njstormwater.org, October 2016

Nwiro, B. (2010) Satellite town Deplorable Roads , retrieved from http://www.thisdaylive.com, October 2016.

Okoro, H.I (2014). Physical Development Planning Sub-components as Veritable Instruments for ordering Integrated Growth and Sustainable Development, Vol. 3, No. 2, March 2014.

Onibokun, A.O (2007). National Physical Development Plan as an instrument for Urban and Regional Development, Presented at the conference of Directors and Heads of planning organisations in Nigeria, Asaba, 2nd November 2007.

Richmond Regional Planning District Commission, (2012) Low Impact Development, , retrieved from http://www.rrpdclid.org, October 2016

Rob, B. (2009) Sustainability Retrieved from http://www.National Institute of Building Sciences.org, February 2016.

Scerri, A. & James, P. (2010) Accounting for Sustainability: Combining Qualitative Research I developing indicators of Sustainability, International Journal of Social Research Methodology 13(1): 41-53.

Science buddies (2015) Design Process, retrieved from http//www.sciencebuddies.com/design process, July 2016.

Simonds, J (1997) Planning-Design Process, retrieved from http//www.rri.wvu.edu/webbook/mcbride/main/html, July 2016.

Steven, B.(Ed) (1999). The Web Book of Regional Science, retrieved from http//www.rri.wvu.edu/webbook/mcbride/main/html, July 2016

Storm Water Blog (2016) What is LID? Five Principles of Low Impact Development, retrieved from http://www.conteches.com/stormwater.blog

The Urban and Regional Planning Law (Decree 88) (1992). Physical Planning in Nigeria, published by the Nigeria Institute of Town Planners, Ilupeju.

United States Environmental Protection Agency (2000) Low Impact Development (LID); A literature Review, retrieved from http://www.epa.gov/aboutepa/aboutoffice_water, February 2015.

United States Geological Survey (2016). The Water Circle, retrieved from http//www.water.usgs.gov/edu/watercircleinfiltration.html.

United States Department of Housing and Urban Development) (2003). The Practice of Low Impact Development, Office of Policy Development and Research. Washington, D.C, Report prepared by NAHB Research Centre inc.

Washington State Department of Ecology (2000) Non-structural Low Impact Development Practices, retrieved from http//www.ecy.wa.gov, July 2016.

White, F., Stallones, L. & Last, J.M (2013) Global Public Health; Ecological Foundations, Oxford University Press, UK.

World Building Design Guide Sustainable Committee (2013) Sustainable Site Planning, retrieved from http//www.wbdg.org/design/ssp, July 2014.

Xtain (2016) Site Analysis, retrieved from http//www.wikipedia/wiki/siteanalysis, July 2016.

Yale School of Medicine (2016). Facilities Planning and Construction, retrieved from http//www.medicine.yale.edu/facilities/process/prelim, August, 2016.

APPENDIX

DEPARTMENT OF ARCHITECTURE, SCHOOL OF ENVIRONMENTAL TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, P.M.B 704, ONDO STATE, NIGERIA.

QUESTIONNAIRE ON THE EFFECT OF LOW IMPACT DEVELOPMENT STRATEGIES ON RESIDENTIAL BUILDING SITE PLAN IN SATELLITE TOWN, LAGOS, NIGERIA

Dear Sir/Madam

This questionnaire is designed to collect data from you on the effect of low impact development strategies on residential building site plan in satellite town, Lagos, Nigeria, with a view of improving environmental quality and human wellbeing within the residential environment. The information you provide will remain strictly confidential and will be used only for academic purposes.

Thank You.

Akagwu, M.
(M.phil/Ph.D Student)

SECTION 1

Respondent's Profile

Please tick in the bracket ( ) provided before each item that is applicable to you

1. Type of Building Ownership: i. Personal ( ) ii. Rental ( )

2. Size of Residential Plot
   i. Half Plot ( ) ii. One Plot ( ) iii. Above One Plot ( )

3. Age of Respondent
   i. 25 – 34 ( ) ii. 35 – 44 ( ) iii. 45 – 54 ( ) iv. 55 & Above ( )

4. Highest Level of Education Completed
   i. Secondary ( ) ii. Graduate ( ) iii. Masters ( ) iv. Doctorate ( )

5. Employment Status
   i. Self Employed ( ) ii. Civil Service ( ) iii. Corporate Org. ( ) iv. Retired ( )

SECTION 2

Assessment of Residential Site Plan Status

Please tick in the bracket ( ) provided before each item that is applicable to your Residential Site

6. Do you have a site design for your residential plot?
   i. Yes ( ) ii. No ( ) iii. Uncertain ( )

7. How many cars can you park in your residential plot?
i. 1 – 2 ( ) ii. 3 – 5 ( ) iii. 6 – 8 ( ) iv. 9 & Above ( )

8. Do you have Open natural spaces in your residential plot?
i. Yes ( ) iii No ( ) iii. Uncertain ( )

9. What is the distance between your building and Approach fence?
i. 1m – 2.9m ( ) ii. 3m – 5.9m ( )iii. 6m – 8.9m ( ) iv. 9m & Above ( )

10. What is the distance between your building and your side fence?
i. 0.1m – 1.9m ( ) ii. 2m – 2.9m ( )iii. 3m – 3.9m ( ) iv. 4m & Above ( )

11. What is the distance between your building and your rear fence?
i. 0.1m – 1.9m ( ) ii. 2m – 2.9m ( )iii. 3m – 3.9m ( ) iv. 4m & Above ( )

12 What is the distance between your Approach fence and external drainage?
i. 0m – 0.5m ( ) ii. 0.6m – 1.0m ( ) iii. 1m – 1.5m ( ) iv. 1.6m & Above ( )

13. Did your Residential plot go through building approval before development?
i. Yes ( ) ii. No ( ) iii. Uncertain ( )

14. Did your Residential plot experience building control monitoring during development?
i. Yes ( ) ii. No ( ) iii. Uncertain ( )

15. Is your residential site development complete?
i. Yes ( ) ii. No ( ) iii. Uncertain ( )

16. Do you have any plan to redesign your residential site in the nearest future?
i. Yes ( ) ii. No ( ) iii. Uncertain ( )

SECTION 3

Assessment of Site Development in relation to Low Impact Development

Please tick in the bracket ( ) provided before each item that is applicable to your Residential Site

17. Did you preserve any natural landscape element during your site development?
i. Yes ( ) ii. No ( )

18. Did you introduce any natural landscape element during your site development?
i. Yes ( ) ii. No ( )

19. What is the state of the space between your building and Approach fence?
i. Paved ( ) ii. Unpaved ( ) iii. Partially paved ( )

20. What is the state of the open space between your building and your side fences?
i. Paved ( ) ii. Unpaved ( ) iii. Partially paved ( )

21. What is the state of the open space between your building and your rear fence?
i. Paved ( ) ii. Unpaved ( ) iii. Partially paved ( )

22. What is the state of the open space between your Approach fence and external drainage?
i. Paved ( ) ii. Unpaved ( ) iii. Partially paved ( )

23. What is the nature of the paved area in your residential site plan?
i. Concrete ( ) ii. Interlocking stones with nylon undelay ( )
iii. Interlocking stones without nylon undelay ( )

24. What is the nature of the unpaved area in your residential site plan?
i. Sand ( ) ii. Grass cover ( ) iii. Sand & Grass ( ) iv. Sand & Shrubs ( ) v. Sand & Trees
vi. Sand, Shrubs & Trees ( ) vii. Grass & Shrubs iv ( ) viii. Grass & Trees ( ) ix. All of the above

SECTION 4:

Assessment of the effects of Low Impact development on Residential Site Development

Please rate the following according the experience in your residential site

		HIGH	AVERAGE	LOW
25	Thermal comfort and heat reduction from site surfaces within setbacks			
26	Site aesthetics and beauty through different surface colours and textures within setbacks			
27	Environmental quality through natural surfaces enhancing plant and animal survival within setbacks			

Please rate the following according your perception

		Strongly Agree	Agree	Indifferent	Disagree	Strongly Disagree
		5	4	3	2	1
28	Increasing and incorporating unpaved areas on residential sites will improve thermal comfort heat reduction site surfaces					
29	Increasing and incorporating unpaved areas on residential sites will enhance site aesthetics and beauty through different surface colours and textures					
30	Increasing and incorporating unpaved areas in residential sites will enhance environmental quality through surfaces enhancing plant and animal survival					

THANK YOU FOR YOUR TIME